

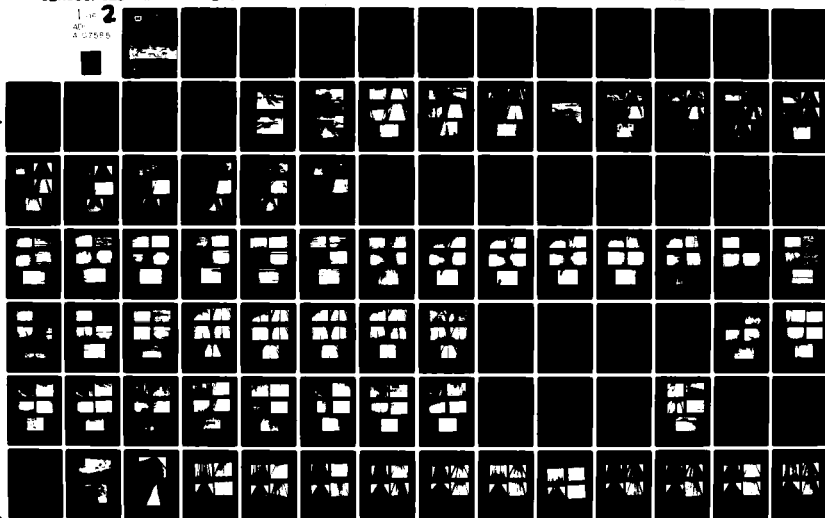
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EVALUATION OF MEMBRANE INTERLAYERS FOR PREVENTION OF CRACK REFL--ETC(U)
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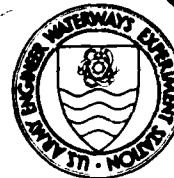


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EVALUATION OF MEMBRANE INTERLAYERS FOR PREVENTION OF CRACK REFLECTION IN THIN OVERLAYS

by

Philip J. Vedros, Jr.

Geotechnical Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

October 1981

Final Report

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Fort McPherson, Georgia 30330
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report is the final report resulting from case studies of pavement performance conducted by the U. S. Army Engineer Waterways Experiment Station as requested by the U. S. Army Forces Command, Fort McPherson, Ga. The purpose of this study was to determine if a layer consisting of an asphalt-rubber membrane or a nonwoven fabric placed under a thin asphaltic concrete overlay (2 in. or less) will stop reflection cracking from occurring in the overlay. Field tests of two asphalt-rubber membrane formulations and three nonwoven (Continued)		

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20. ABSTRACT (Continued).

fabrics were placed on roads and airfield pavements at five Army installations in various areas of the United States. The initial report covered the actual construction and performance of the materials for a period of 6 months after construction. This report covers the performance of the materials after a period of from 3 to 4 years, during which annual inspections were made. The results of the field tests indicate that in a cold environment the use of these membranes does not prevent or retard reflection cracking from occurring. The asphalt-rubber material was not evaluated over a long enough period of time in a warm climate to determine if reflection cracking was sufficiently prevented or retarded to warrant use of this material.

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PREFACE

At the request of the Headquarters, U. S. Army Forces Command (FORSCOM), Fort McPherson, Georgia, the U. S. Army Engineer Waterways Experiment Station (WES) participated in an investigation of asphalt-rubber membranes and nonwoven fabrics as stress-absorbing layers for prevention of reflection cracking through thin overlays. Authority for the WES to participate in this program is contained in a letter dated 14 February 1977 from FORSCOM entitled "Testing of Asphalt-Rubber Membranes." The Office, Chief of Engineers, U. S. Army, funded this project during the period 1979-1981 under FY 80 authority for Facilities Investigation and Studies Program (O&MA).

A number of representatives of the U. S. Army Corps of Engineers and the manufacturers of the materials used in the tests were involved in the placement of the materials and in the annual inspections made since construction. Personnel from the WES participating in the study were Messrs. A. H. Joseph, S. L. Webster, P. J. Vedros, Jr., P. S. McCaffrey, Jr., and S. J. Alford of the Geotechnical Laboratory (GL), and V. Magee, Jr., and D. B. Larr, Jr., of the Photographic Branch. Manufacturer representatives involved in the study were: Messrs. E. S. Gothard and Tom Barnett, Monsanto Textiles Company; Messrs. W. S. Harmon, Danny Campbell, T. G. Collins, and J. Ray Mullarkey, Celanese Fibers Marketing Company; Mr. Didrik A. Voss, Mirafi Systems, Wiley-Bailey, Incorporated; Messrs. Dick Armstrong, H. G. Lansdon, Bill Meggison, Jim Slatten, Frank Ladwig, and Peter Gagan, Sahuaro Petroleum and Asphalt Company; Messrs. Jim Bagley, Bob Holbrook, Ed Hamlin, Bob Huff, Norm Peterson, and Peter Winkler, Arizona Refining Company; Mr. R. J. Dzimian, U. S. Rubber Reclaiming Company; and Messrs. Dale Levy, Dave Spaulding, and Jim Dykes, Phillips Fibers Corporation.

Action officers for FORSCOM for the project were: Mr. F. W. B. Taylor, Headquarters; Major D. B. Murray, Directorate of Facilities Engineering (DFAE), Fort Devens; Messrs. Lyman Smith and Jim Packard, DFAE, Fort Lewis; Mr. T. D. Houston, DFAE, Fort Stewart; Messrs. Tom Russell and Bony Jacinto, DFAE, Fort Carson; and Mr. Herb Carter, DFAE, Fort Polk.

This report was prepared by Mr. P. J. Vedros, Jr., Pavement Systems Division (PSD), under the direct supervision of Mr. A. H. Joseph, Chief, PSD, and the general supervision of Dr. W. E. Marcuson III, Chief, GL, and Dr. P. F. Hadala, Assistant Chief, GL.

COL John L. Cannon, CE, COL Nelson P. Conover, CE, and COL Tilford C. Creel, CE, were Commanders and Directors of the WES during the conduct of this study and preparation of this report. Mr. Frederick R. Brown was Technical Director.

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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI)
UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
Fahrenheit degrees	5/9	Celsius degrees or Kelvins*
feet	0.3048	metres
inches	25.4	millimetres
ounces per square yard (mass)	33.90575	grams per square metre
square yards	0.8361274	square metres

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: $C = (5/9)(F - 32)$. To obtain Kelvin (K) readings, use: $K = (5/9)(F - 32) + 273.15$.

EVALUATION OF MEMBRANE INTERLAYERS FOR PREVENTION
OF CRACK REFLECTION IN THIN OVERLAYS

PART I: INTRODUCTION

Background

1. The test sites selected by the U. S. Army Forces Command (FORSCOM) for the sprayed asphalt-rubber and fabric membrane materials tests were located at Fort Lewis, Washington; Fort Devens, Massachusetts; Fort Stewart, Georgia; Fort Polk, Louisiana; and Fort Carson, Colorado.

2. The asphalt-rubber membranes used in this study consisted of two formulations in which ground tire rubber is mixed with asphalt, sprayed on the existing surface, and then covered with aggregate chips prior to placement of the overlay. One formulation developed by Sahuaro Petroleum and Asphalt Company consists of mixing approximately 25 percent granulated crumb rubber (100 percent vulcanized) with 75 percent asphalt. About 5 to 7 percent kerosene is normally added to this mixture. The other formulation (C274) developed by the U. S. Rubber Reclaiming Company consists of mixing approximately 20 percent ground rubber (blend of 40 percent powdered devulcanized and 60 percent ground vulcanized) with 80 percent asphalt. About 2 percent extender oil is normally added to this mixture.

3. The fabrics used in this study consisted of a 100 percent nonwoven polyester with the trade name Bidim (C-22), marketed by Monsanto Textiles Company; a nonwoven polypropylene and nylon sheathed polypropylene with the trade name Mirafi (140), marketed by Celanese Fibers Marketing Company; and a nonwoven polypropylene with the trade name Petro-mat, marketed by Phillips Fibers Corporation. Each of these fabrics weighed 4.5 oz/sq yd.*

* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 4.

4. An interim report Miscellaneous Paper GL-79-4, dated March 1979, and entitled "Evaluation of the Effectiveness of Membranes for Prevention of Crack Reflection in Thin Overlays" was published for this study. This interim report covered the construction phase of the test installations and the performance after a period of 6 months of service. Annual inspections have been made of the test installations since construction, and this final report covers the performance of the materials through June 1981.

Purpose

5. The purpose of this study was to determine if a layer consisting of an asphalt-rubber membrane or a nonwoven fabric placed under a thin asphaltic concrete overlay (2 in. or less) will stop reflection cracking from occurring in the overlay.

Analysis of Performance

6. The performance of the various test materials were monitored from the period just before the application of the materials in 1977 to June 1981, which was the date of the last inspection. The progression of reflection cracking was followed by photographing selected areas in each test section. Before the application of the test materials, an area 25 by 25 ft was selected in each test section, and a photograph was made of this marked-off area. In some cases, the length of the cracks was measured and recorded. The cracks in this marked-off area were plotted on a transparency so that a detailed record of all cracks were recorded. A photograph of each selected test area was made on an annual basis to follow the progression of any reflection cracking that may occur in the section. In early inspections, photographers from the installations were utilized, but they failed to duplicate the same view as shown for the initial photograph. Thus, it was necessary to use a photographer from the WES.

PART 11: FORT LEWIS, WASHINGTON

Test Locations

7. Figure 1 shows a layout of the test locations on Faith Avenue and Second Division Drive. The test sections on Faith Avenue were each 400 ft long and the width of the roadway. A 200-ft section of each fabric and the asphalt-rubber membrane was placed on each side of the median. A 1-1/2-in. asphaltic concrete overlay was placed over each material, and the control section was a standard 1-1/2-in. asphaltic concrete overlay over the existing pavement. As noted in Figure 1, the Sahuaro rubber material was placed in two locations on Second Division Drive. At one location, approximately 2330 ft long and the width of the roadway, the asphalt-rubber membrane was covered with chips that had been precoated with asphalt, and at the other location, approximately 1100 ft long, the membrane was covered with regular washed uncoated chips. The U. S. Rubber asphalt-rubber membrane, approximately 2450 ft long, was covered with precoated chips. The performance of the two asphalt-rubber materials without overlays was to be compared with the performance of a standard 1-in. overlay, which was considered to be a control section.

Performance of Test Materials

8. The cracking in the existing pavement surface on Faith Avenue and Second Division Drive was very minor with crack widths not exceeding 1/4-in. The chip seal of asphalt rubber was placed on Second Division Drive because of the minor amount of cracking observed in the roadway. The test sections were placed during the period 4-12 October 1977. The weather was cloudy, damp and cool, and far from ideal for placement of these materials. Some construction problems were encountered because of damp pavements.

Second Division Drive

9. Approximately 5 months after construction, the chip seal on

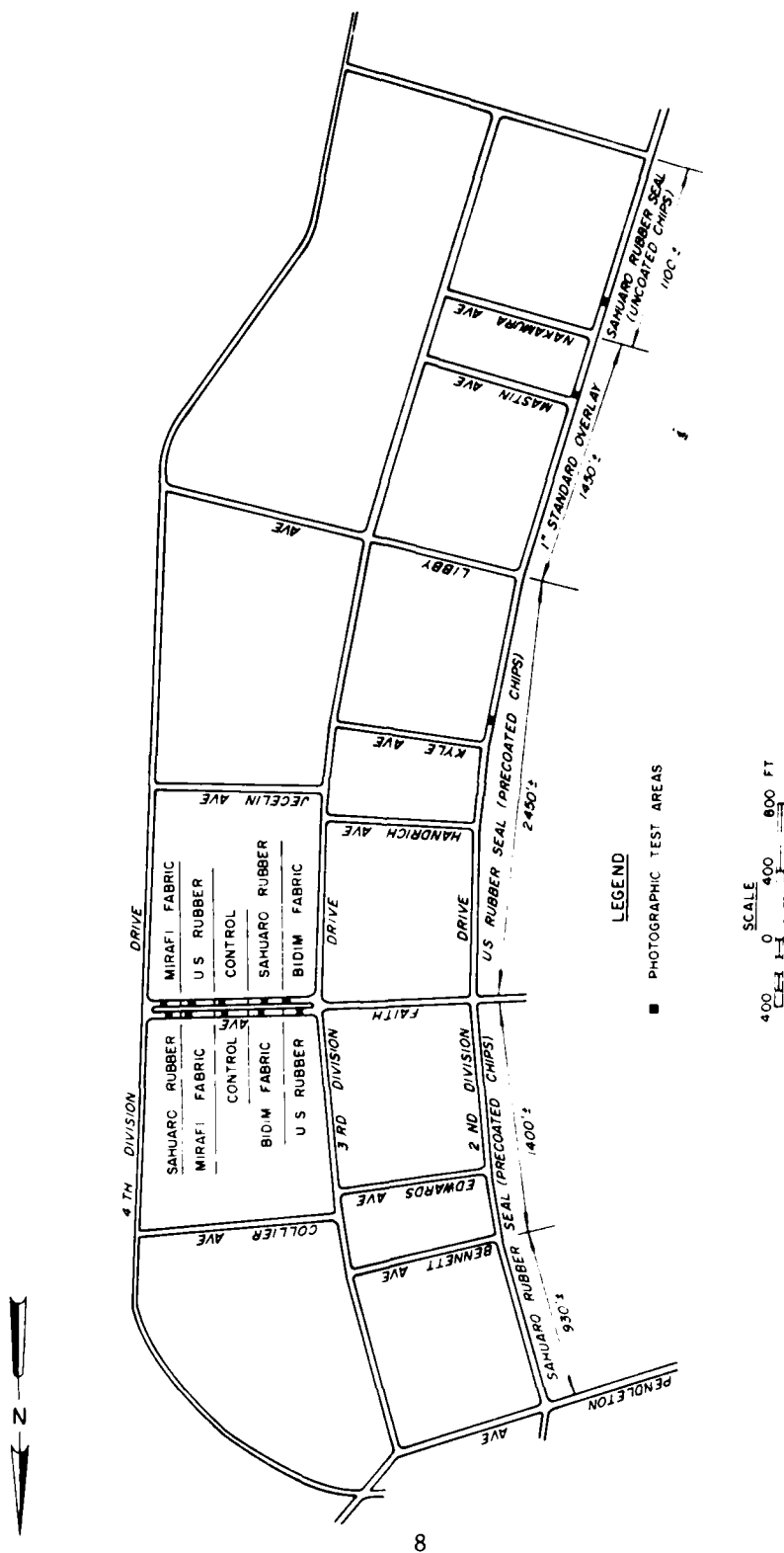


Figure 1. Location of test areas, Fort Lewis, Washington

Second Division Drive was observed to be ravelling very severely in the wheel paths of the automobiles and at turn outs from the roadway (Photo 1). This condition was occurring mainly in the Sahuaro asphalt rubber sections, in both the uncoated and precoated chip areas. The U. S. Rubber chip seal area was observed to have a bare spot along the center line where the material was not applied during construction (Photo 2). The loose chips were swept from the roadway prior to the inspection in 1978 and very little change in the surface condition of the roadway has occurred since that time. The roadway has been inspected on an annual basis, and Photos 3 and 4 indicate the general condition at the time of the inspection in June 1981. The 25-ft-wide areas marked off to monitor the cracking by photographic means (Photos 5-7) indicated that only a very small crack has reflected in the section for the U. S. Rubber material. The control section of a standard 1-in. overlay was in excellent condition.

Faith Avenue

10. The cracking on Faith Avenue before application of the test materials was minor and tended to be localized. The cracks were sealed before application of the test materials (Photo 8). No measurement of the length of the cracking in each photographic test area was made of the original pavement before application of the test materials. The original cracking pattern can be seen in Photos 9 through 18. The first evidence of any cracking in the overlay on Faith Avenue was observed in February 1978. A fine hairline crack in the Mirafi 140 section on the southside was determined to be caused by a wrinkle in the fabric during construction (Photo 19). A reflection crack in the control section on the north side of Faith Avenue was observed in May 1978 (Photo 20). Table 1 presents a summary of the estimated percentage of reflection cracking that was observed in all test areas on Faith Avenue. As noted, the only sections that had cracking were the two sections of the Mirafi 140 fabric and one control section.

Analysis of Findings

11. As indicated in paragraph 8, the cracking in the pavements at

Fort Lewis was very minor before application of the test materials; for this reason, only limited information is available on the ability of the materials to stop reflection cracking in a 1-1/2-in. overlay. After a 4-year period, the Bidim fabric and asphalt-rubber mixtures on Faith Avenue appear to be performing slightly better than a standard overlay; however, one control section has not indicated any cracking. The test section did show that wrinkling in the Mirafi 140 fabric can create problems in thin overlays. The asphalt-rubber chip seal on Second Division Drive did not provide a riding surface as good as a standard 1-in. overlay. It is recognized that the weather was unfavorable at the time the chip seal was placed and a better performance could possibly be realized under more ideal conditions. Thus, it is apparent that constructing seal coats with rubberized asphalt is for more difficult than with cut back or liquid asphalts.

Table 1
Summary of Performance of Test Materials on Faith Avenue

<u>Section No.</u>	<u>Material</u>	<u>Estimated Percent of Cracks Reflected</u>
1	Bidim	0
2	Sahuaro	0
3	Control	0
4	U. S. Rubber	0
5	Mirafi	10 (additional cracks from wrinkle)
6	Sahuaro	0
7	Mirafi	0 (cracks observed caused by wrinkle in fabric)
8	Control	100
9	Bidim	0
10	U. S. Rubber	0



Photo 1. Asphalt-rubber seal placed by Sahuaro
ravelling in traffic wheel paths (note buildup
of loose chips at curb line)



Photo 2. U. S. Rubber seal with bare spot at
center line. Area did not receive rubberized
material during construction



Photo 3. View of U. S. Rubber chip area, Second Division Drive, June 1981



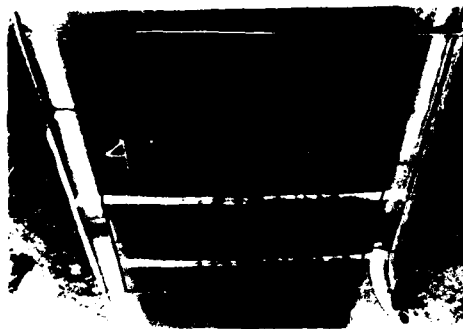
Photo 4. View of Sahuaro precoated chip area, Second Division Drive, June 1981



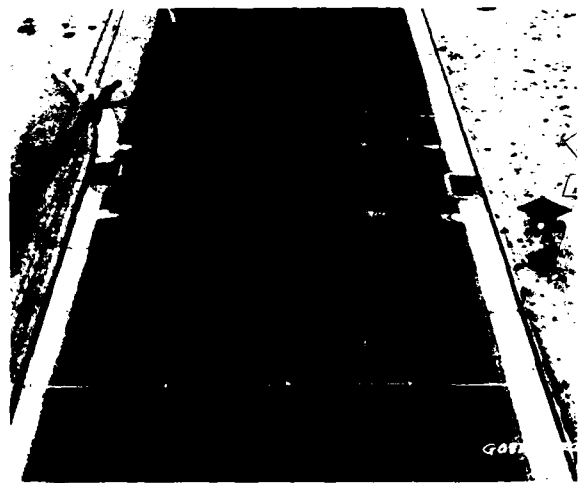
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July 1979



May 1978

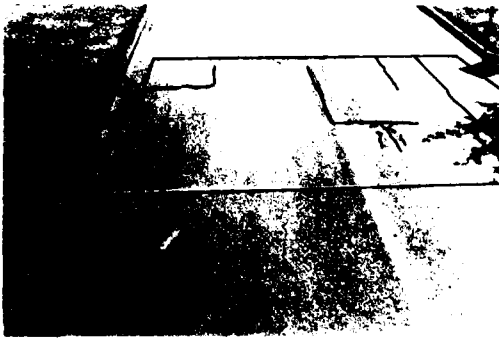


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June 1981

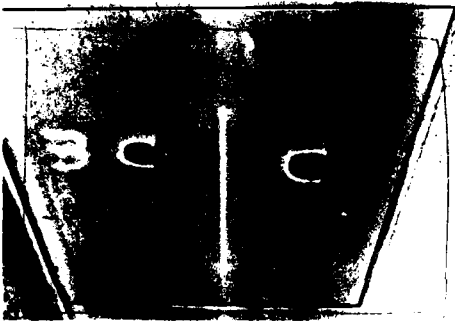
Photo 5. U. S. Rubber section, Second Division Drive



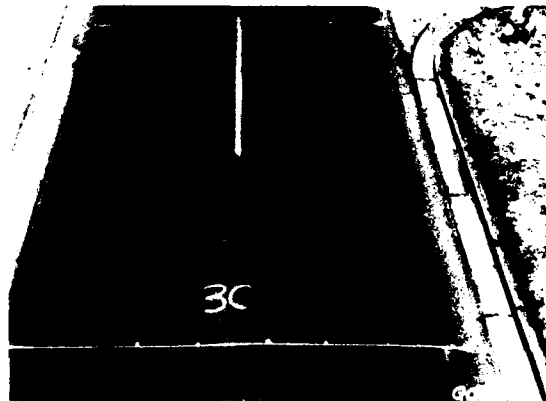
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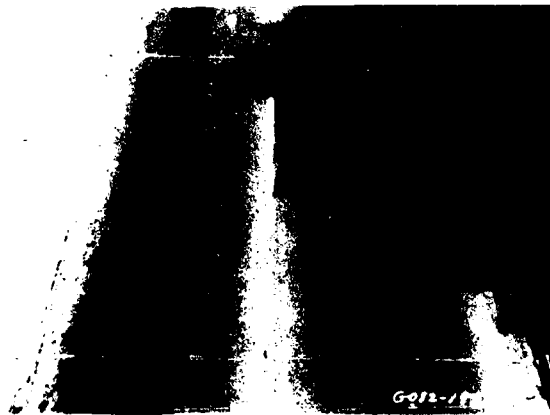
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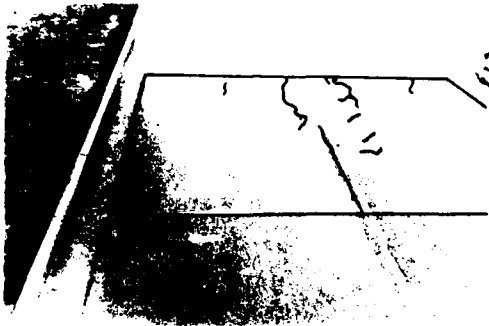


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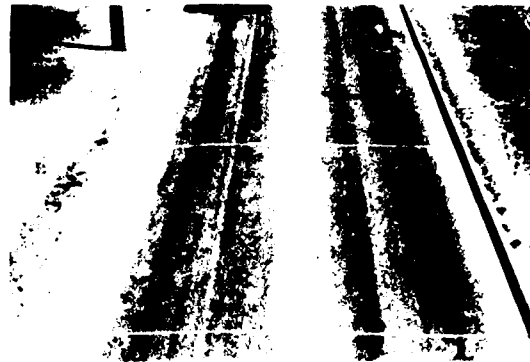


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Photo 6. Control section (1-in. standard overlay),
Second Division Drive



May 1977



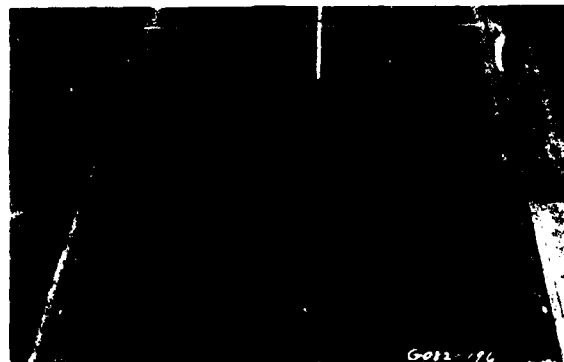
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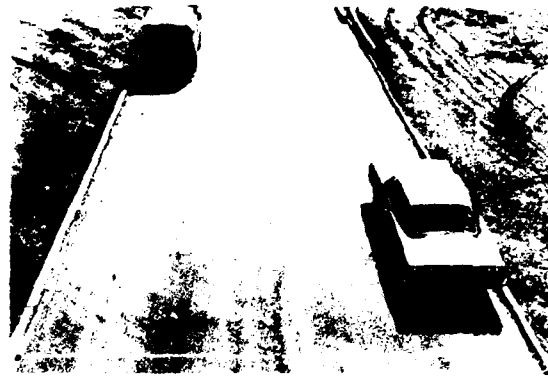
Photo 7. Sahuaro rubber section (uncoated chips),
Second Division Drive



Photo 8. Cracks on Faith Avenue sealed
with AR-4000 asphalt



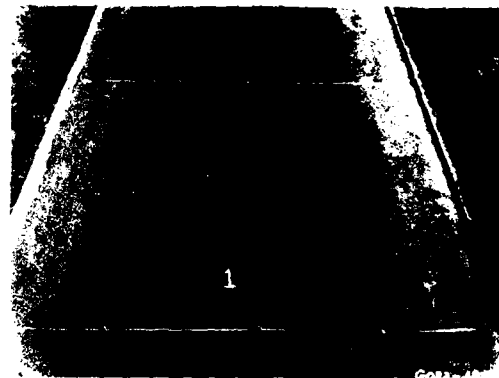
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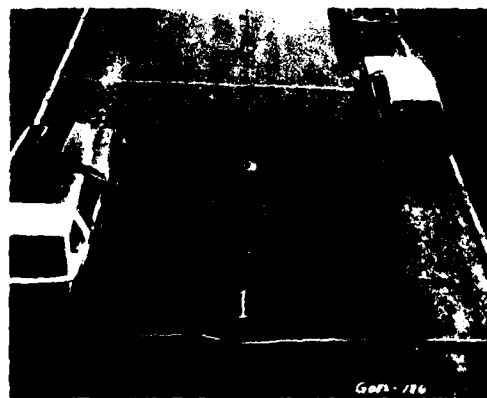
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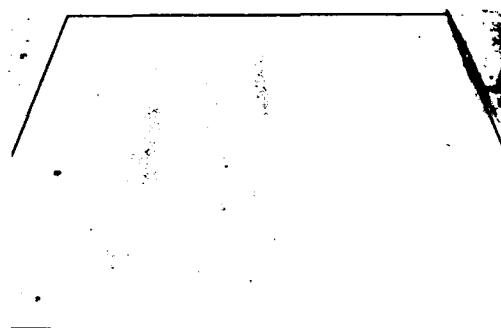
Photo 9. Bidim C-22 fabric section, south side of Faith Avenue



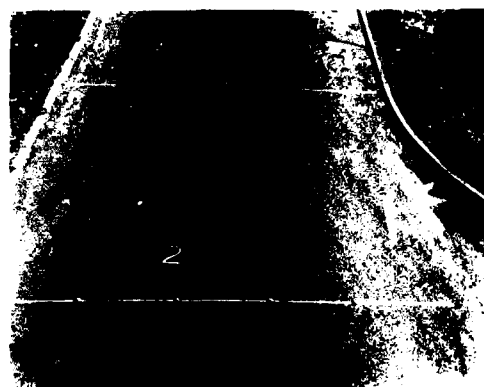
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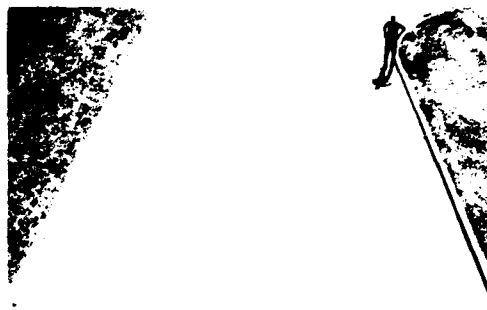


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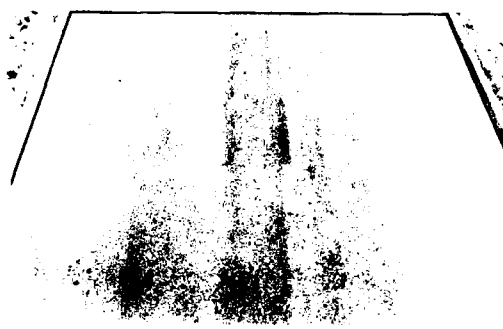
Photo 10. Sahuaro rubber section, south side of Faith Avenue



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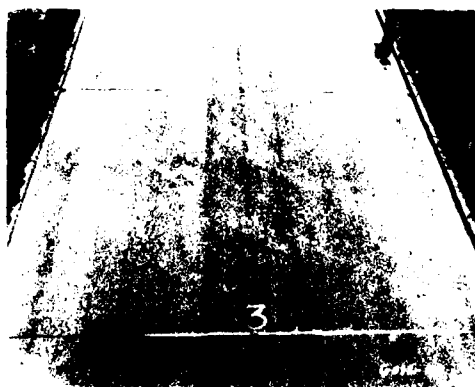
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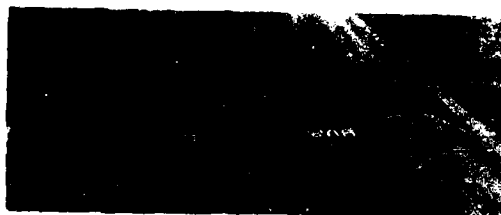


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Photo 11. Control section, south side of Faith Avenue



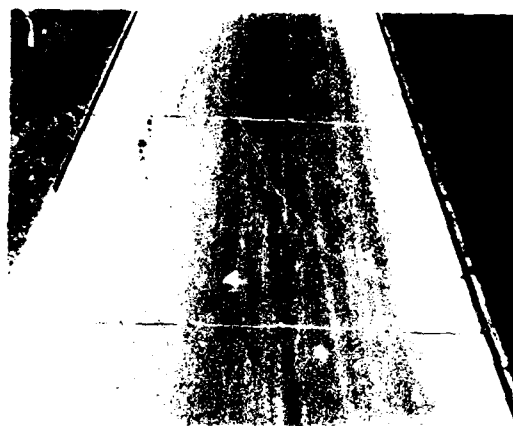
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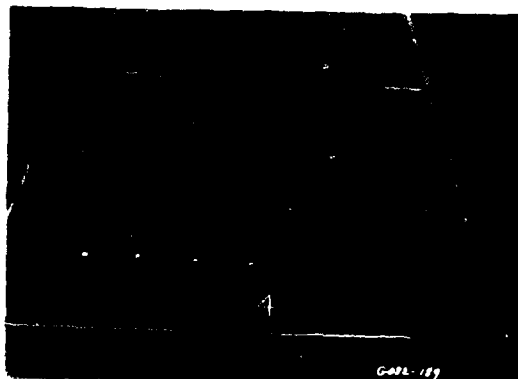
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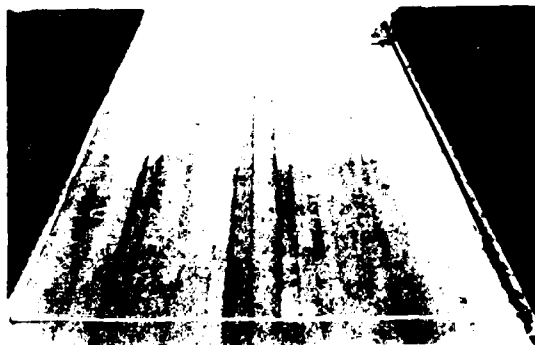


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Photo 12. U. S. Rubber section, south side of Faith Avenue



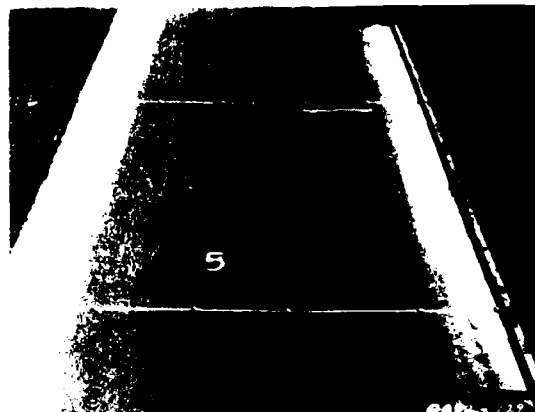
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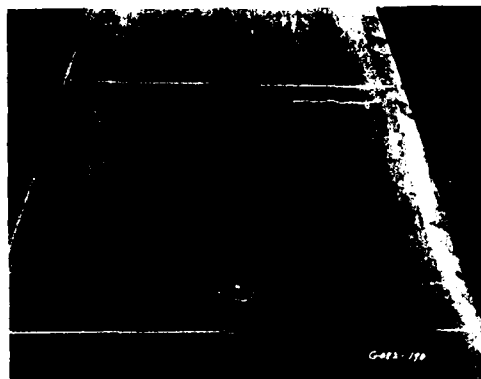
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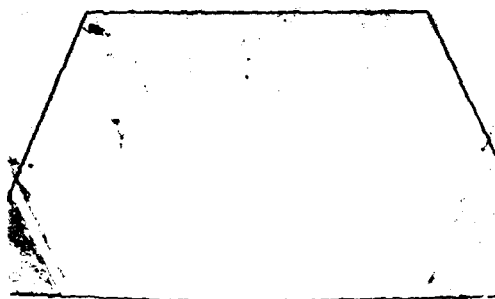
Photo 13. Mirafi 140 fabric section, south side of Faith Avenue



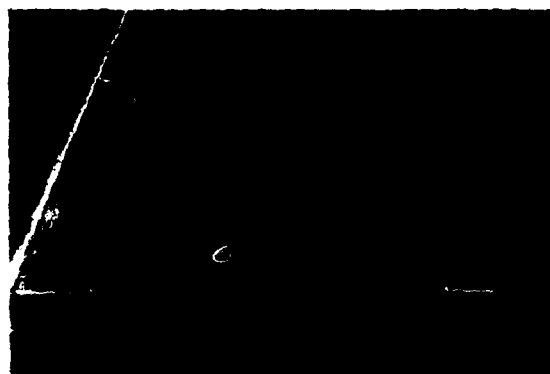
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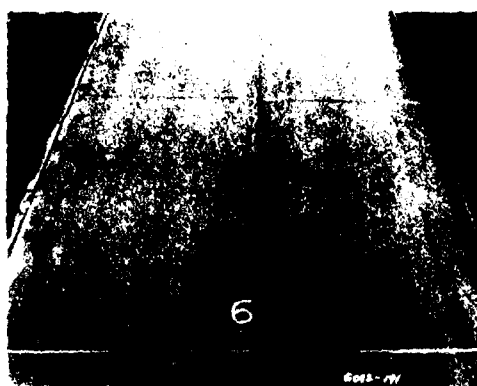
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Photo 14. Sahuaro rubber section, north side of Faith Avenue



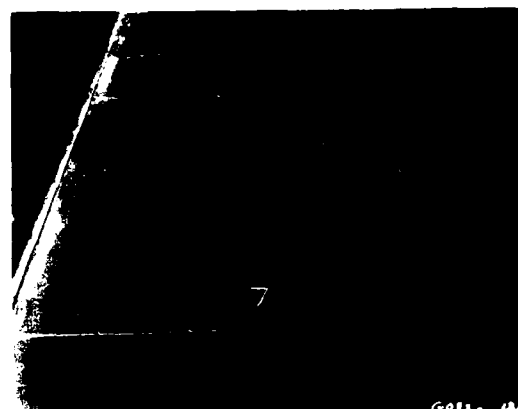
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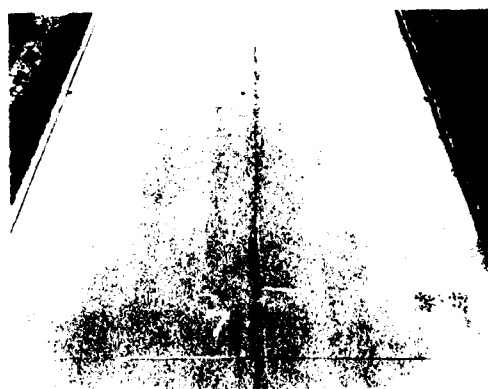
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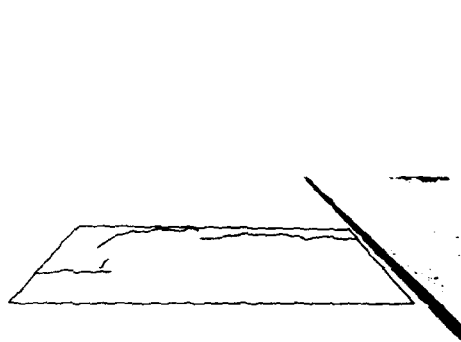


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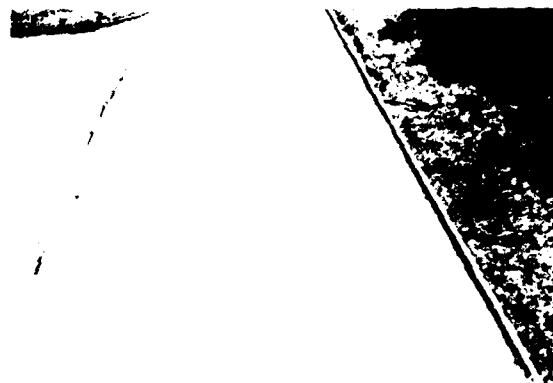


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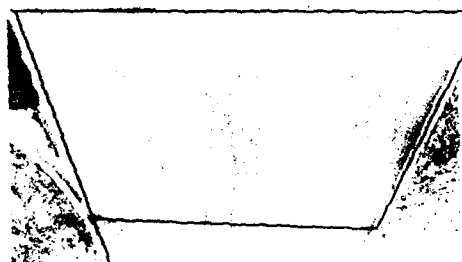
Photo 15. Mirafi 140 fabric section, north side of Faith Avenue



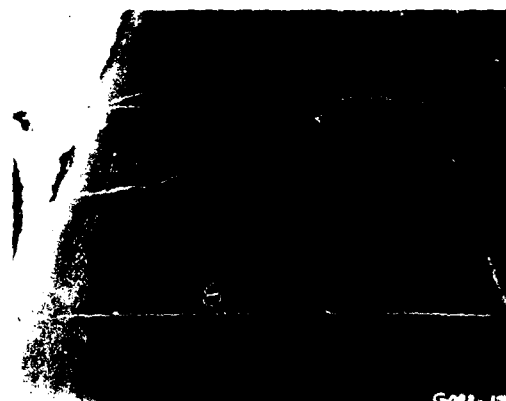
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July 1979



May 1978

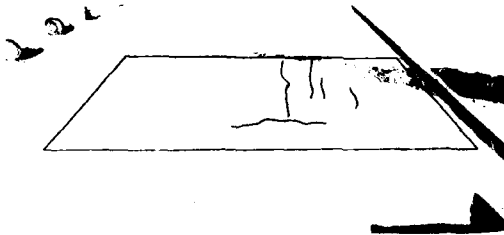


August 1980



June 1981

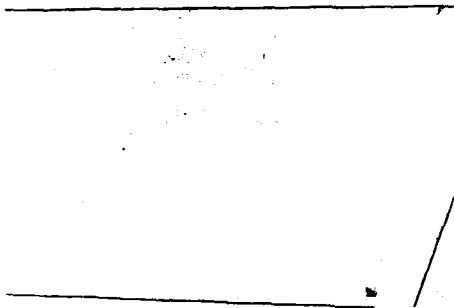
Photo 16. Control section, north side of Faith Avenue



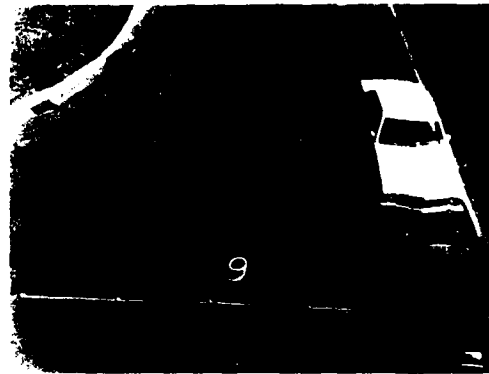
May 1977



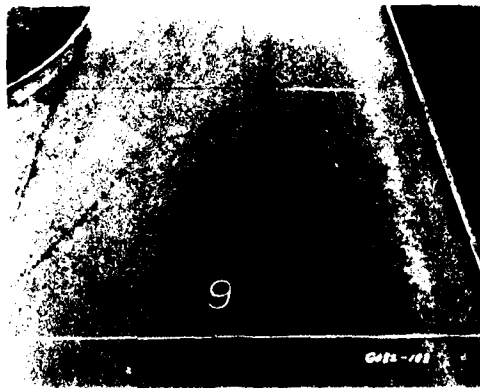
July 1979



May 1978



August 1980

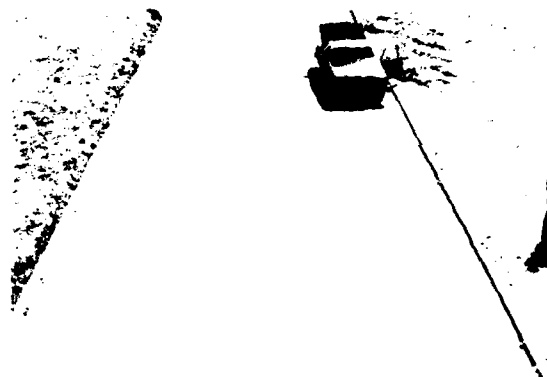


June 1981

Photo 17. Bidim C-22 fabric section, north side of Faith Avenue



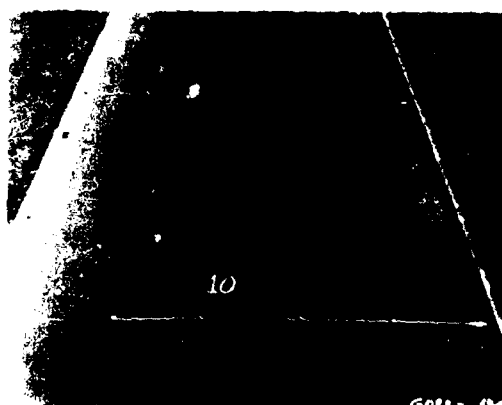
May 1977



July 1979



May 1978



August 1980



June 1981

Photo 18. U. S. Rubber section, north side of Faith Avenue

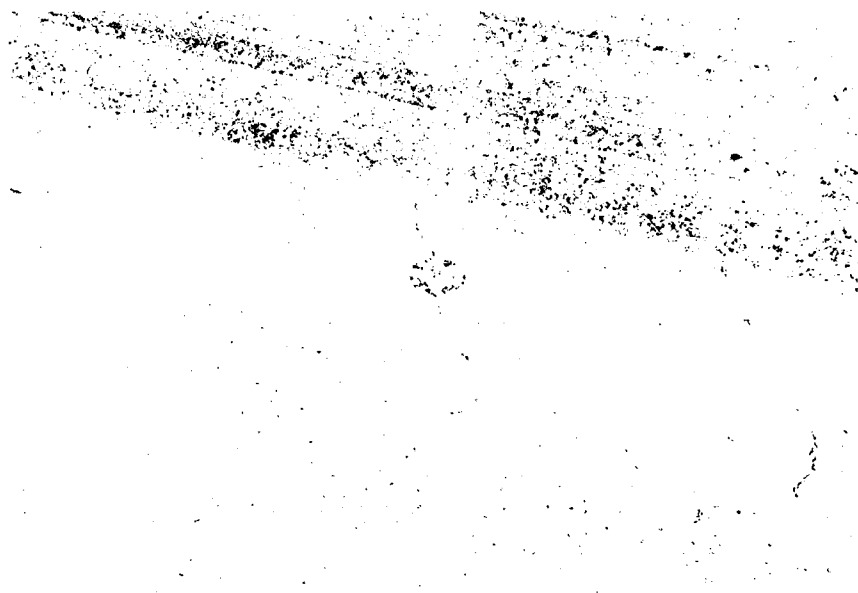


Photo 19. Fine hairline crack created in
overlay by wrinkle in Mirafi fabric



Photo 20. Reflection crack in control section
on north side of Faith Avenue

PART III: FORT DEVENS, MASSACHUSETTS

Test Locations

11. Figure 2 shows a layout of the test locations on Moore Army Airfield (AAF) and Barnum Road. As noted in this figure, the test sections at Moore AAF were located on three different areas of the airfield. Four 100- by 200-ft test areas of the fabric and asphalt-rubber membrane materials were placed on the NW-SE runway, four 100- by 80-ft areas on the N-S runway, and four 100- by 100-ft areas on the apron. Each test area was overlaid with 2 in. of asphaltic concrete, and the control sections consisted of a standard 2-in. asphaltic concrete overlay. The test areas on Barnum Road (Figure 2) consisted of fabric sections 325 ft long by 28 ft wide and the asphalt rubber sections 400 ft long by 28 ft wide. These areas were also overlaid with 2 in. of asphaltic concrete. The test areas were placed at Fort Devens during the period from 7 October to 8 November 1977. The weather was clear and cool, with morning temperatures in the low 40-deg range.

Performance of Test Materials

NW-SE runway

12. The cracking in the pavement surface on this runway appeared to be typical reflection cracking from soil-cement base material. All cracks on the NW-SE runway had been sealed in 1973, but the cracks that developed since that time had not been sealed at the time of these tests. The unsealed cracks ranged in width from 1/4 to 1/2-in. About 20 percent of the cracks were unsealed in the selected test locations. As shown in Figure 2, there were six test sections on the NW-SE runway with two of the sections used as a control. Photos 21 through 26 indicate the crack pattern that existed in the selected photographic areas before placement of the test materials and the progression of reflection cracking through the materials at the end of the last inspection in June 1981. Table 2 presents a summary of the percentage of cracking

that has reflected over the 4-year period the sections were monitored. Sections 1 through 6 were located on the NW-SE runway. Table 3 indicates the percentage of cracks for each area of the airfield and roadway. As noted in Table 3, the U. S. Rubber section indicated the lowest crack reflection at 44.8 percent and the Sahuaro rubber the highest at 88.8 percent.

N-S runway

13. The cracking in the pavement surface on this runway was not as severe and numerous as on the NW-SE runway. The cracks were generally about 1/4-in. in width and had never been sealed. Sections numbered 7 through 12 are located on this runway. Photos 27 through 32 indicate the crack pattern that existed in the selected photographic areas before placement of the test materials and the progression of reflection cracking with time. Table 2 indicates the percentage of cracking for Sections 7 through 12, and Table 3 summarizes the data for each facility. As noted in Table 3, the control section indicated the lowest crack reflection at 53.3 percent, and the Mirafi 140 fabric the highest at 97.0 percent.

Apron

14. The cracking in the pavement surface on the apron area was similar to that observed on the NW-SE runway. The cracks ranged in width from 1/4 to 1/2-in., and in the selected photographic test areas, the cracks in the northern half of the areas were sealed before installation of test materials and left unsealed in the southern half. As shown in Figure 2, there were five test sections located on the apron area. Photos 33 through 37 indicate the crack pattern that existed in the selected test areas before placement of the test materials and the progression of reflection cracking through these materials to the end of the last inspection in June 1981. These photographs also show that the cracks reflected in the northern half of the section the same as in the southern portion, so sealing the cracks did not affect the performance. Table 2 indicates the percentage of cracking for Sections 13 through 17, and Table 3 summarizes the data for each facility. As noted in Table 3, the U. S. Rubber section indicated the lowest crack

reflection at 39.6 percent, and the Bidim fabric the highest at 62.2 percent.

Barnum Road

15. The cracking pattern in the pavement surface on Barnum Road was different from that found on the airfield, probably due to the difference in base material. The base material on Barnum Road consisted of a 5- to 7-in. layer of 3-in. maximum size asphalt stabilized crushed rock. The few cracks in the test areas had been sealed sometime prior to this test program. As shown in Figure 2, there were five test sections placed on Barnum Road. Photos 38 through 42 indicate the crack pattern that existed in the selected photographic areas before placement of test materials and the progression of reflection cracking through these materials to the end of the last inspection in June 1981. Table 2 indicates the percentage of cracking for Sections 18 through 22, and Table 3 summarizes the data for each facility. As noted in Table 3, the Sahuaro rubber section indicated the lowest crack reflection at 8.9 percent, and the Mirafi 140 fabric the highest at 60.4 percent.

Analysis of Findings

16. It was reported that the 1977-78 winter was one of the coldest this area had experienced in the past 50 years. The winters of 1978-79 and 1979-80 were fairly mild, and in 1980-81 the winter was cold again. However, the materials have been in place long enough to give a good indication of the effects of the environment (expansion and contraction). Examining the performance of the materials in each facility (Table 3) indicates that the U. S. Rubber had better performance in two areas, Sahuaro in one, and the control in the other. Combining the NW-SE runway with the apron area (both had similar types of crack patterns in the original pavement), the U. S. Rubber material averages the lowest crack reflection at 42.2 percent as compared with the control area at 63.9 percent. Combining all three areas on the airfield, the U. S. Rubber material averages the lowest crack reflection at 50.6 percent as compared with the control area at 58.3 percent.

Finally, averaging all four test areas at Fort Devens, the U. S. Rubber material still has the lowest crack reflection at 46.2 percent as compared with the control areas at a 53.8 percent.

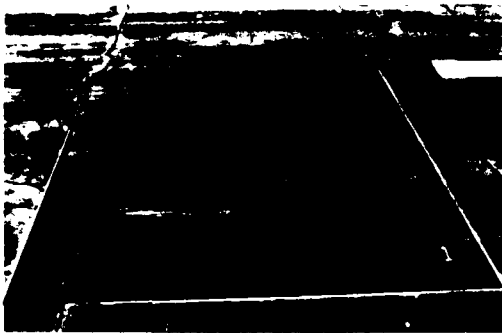
17. During the conduct of this study, it was possible to discuss and observe the performance of the same type fabrics and asphalt-rubber membranes, which were placed on a highway by the New Hampshire Highway Department. None of the materials stopped the transverse cracking that appears on highways in this area of the country from reflecting through the overlay. However, it was stated that the cracks in the fabric areas gave a smooth ride, whereas a bump was felt when passing over the crack in the asphalt-rubber treated area. The feeling by Highway Department personnel was that the fabric may possibly help the performance by providing a waterproof membrane during the free-thaw cycle.

Table 2
Summary of Performance of Test Sections at Fort Devens

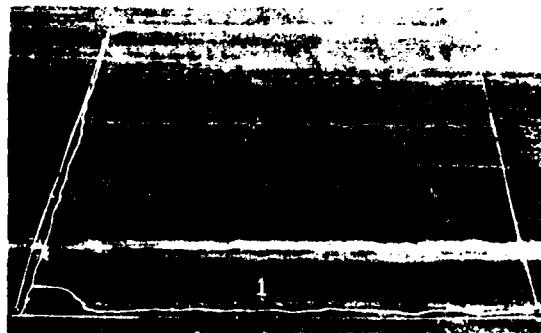
Section No.	Test Material	Original Length of Cracks, ft	Percent of Cracks Reflected			
			June 1978	August 1979	June 1980	June 1981
1	U. S. Rubber	154.0	0	34.4	34.4	44.8
2	Control	88.0	0	49.9	49.9	50.0
3	Bidim	92.0	0	54.4	60.2	85.2
4	Mirafi	161.0	0	33.8	41.3	48.6
5	Control	118.0	0	70.7	70.7	78.0
6	Sahuaro	69.0	0	27.5	74.9	88.8
7	Sahuaro	94.0	0	25.5	31.3	73.1
8	Control	73.0	0	66.7	66.7	67.4
9	Pidim	57.0	0	29.5	38.6	76.5
10	Mirafi	43.0	0	65.6	84.0	97.0
11	U. S. Rubber	84.0	0	58.3	58.8	67.5
12	Control	99.0	0	26.3	28.3	39.1
13	Bidim	79.0	0	61.4	62.2	62.2
14	Mirafi	90.0	0	32.8	46.4	46.4
15	Sahuaro	84.5	0	37.3	41.0	48.8
16	U. S. Rubber	130.0	0	20.2	39.6	39.6
17	Control	122.5	0	37.0	37.1	57.5
18	Sahuaro	65.0	0	0	0	8.9
19	U. S. Rubber	60.0	0	9.8	15.2	33.0
20	Mirafi	69.0	0	12.2	14.8	60.4
21	Bidim	48.0	0	16.3	23.5	57.9
22	Control	80.0	0	0	0	30.5

Table 3
Summary of Performance for Each Test Area at Fort Devens

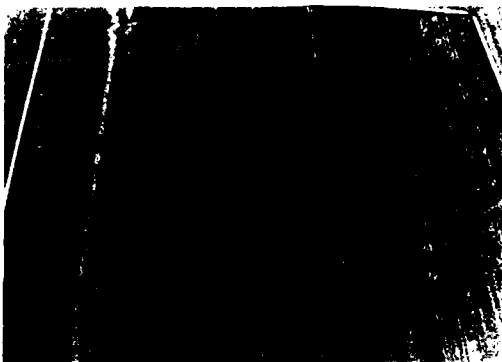
Location	Percent of Cracks Reflected				
	Control	Bidim	Mirafi	U. S. Rubber	Sahuaro
NW-SE runway	64.0	85.2	48.6	44.8	88.8
N-S runway	53.3	76.5	97.0	67.5	73.1
Apron	57.5	62.2	46.4	39.6	48.8
Barnum Road	30.5	57.9	60.4	33.0	8.9
Average for NW-SE runway and apron	63.9	73.7	47.5	42.2	68.8
Average for NW-SE runway, N-S runway, and apron	58.3	74.6	64.0	50.6	70.3
Average for all areas	53.8	70.5	63.1	46.2	54.9



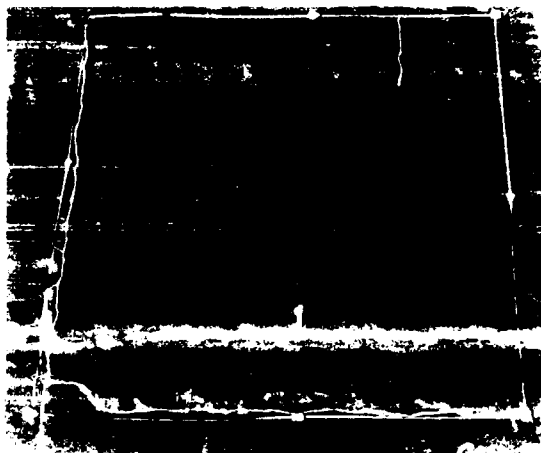
April 1977



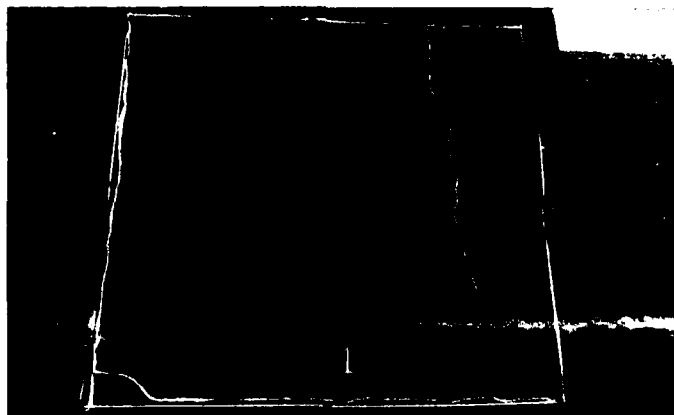
August 1979



June 1978



June 1980



June 1981

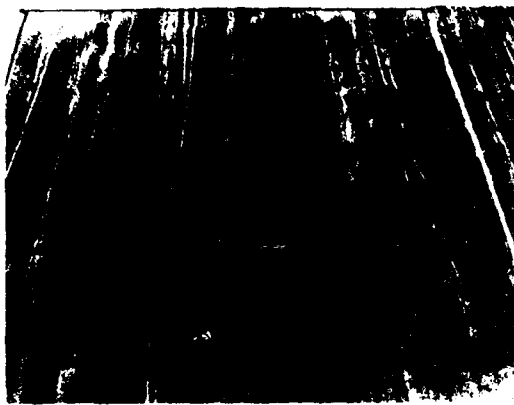
Photo 21. U. S. Rubber section, NW-SE runway



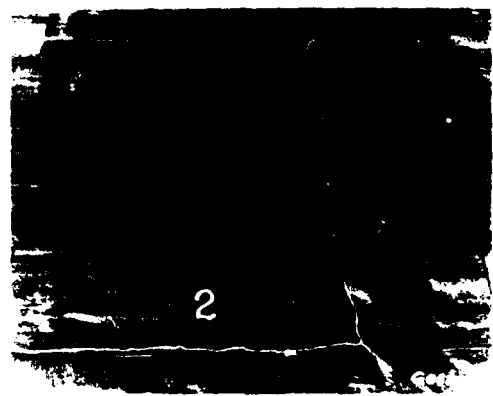
April 1977



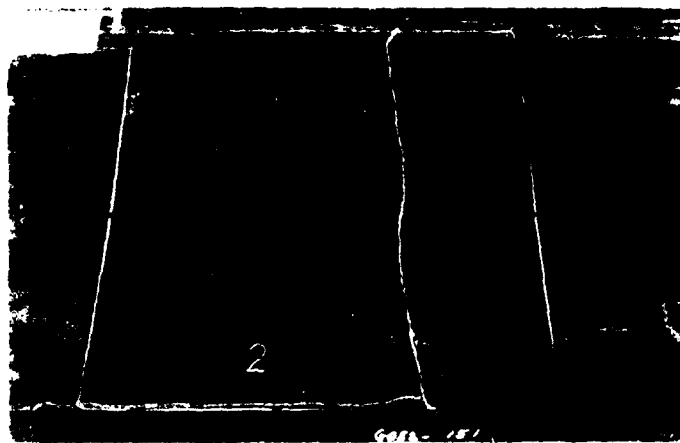
August 1979



June 1978



June 1980

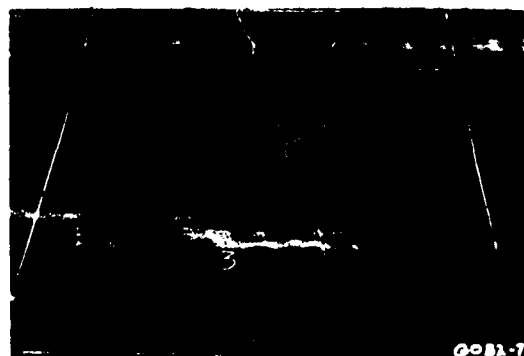


June 1981

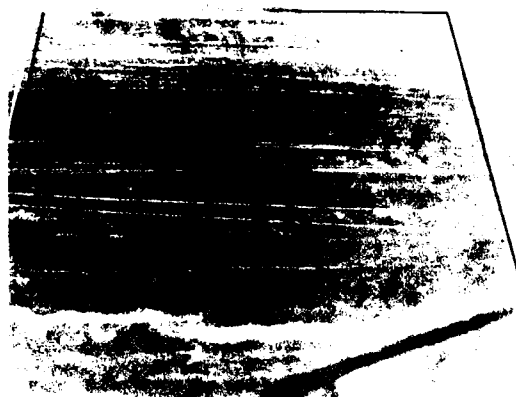
Photo 22. Control section, NW-SE runway-station 19+50 to 21+50



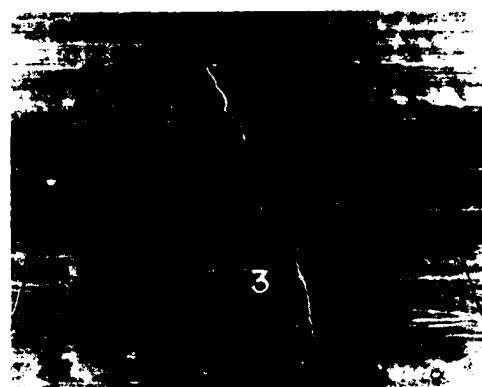
April 1977



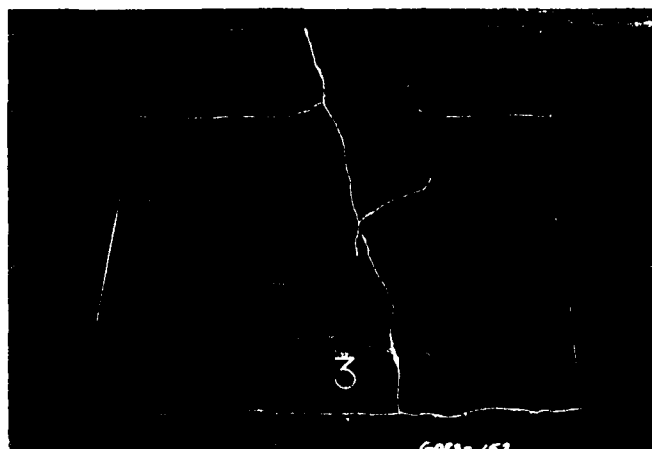
August 1979



June 1978



June 1980

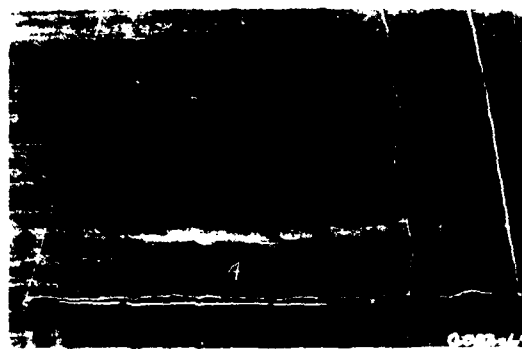


June 1981

Photo 23. Bidim C-22 fabric section, NW-SE runway



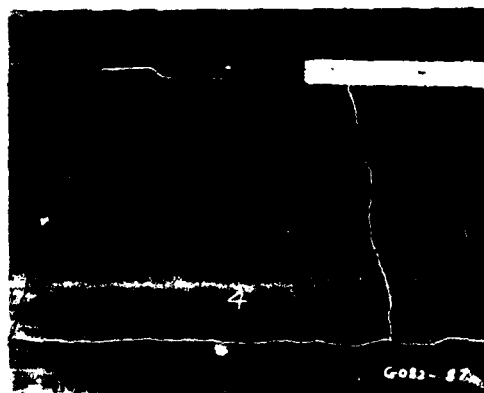
April 1977



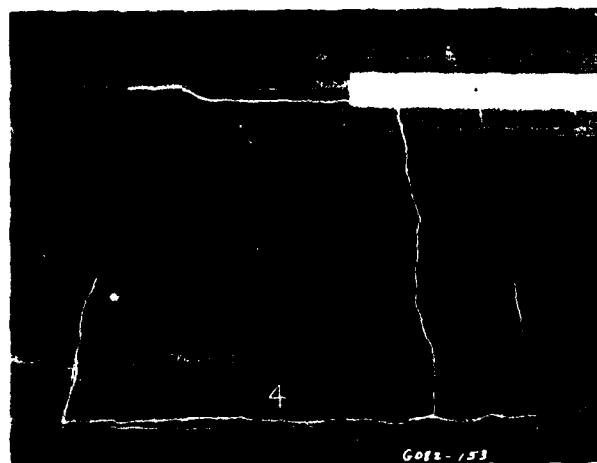
August 1979



June 1978

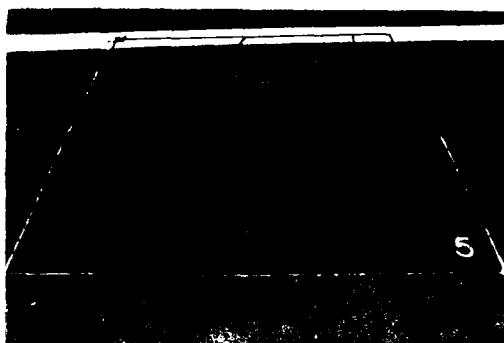


June 1980

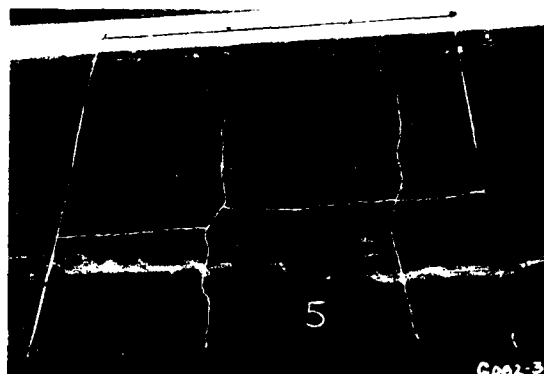


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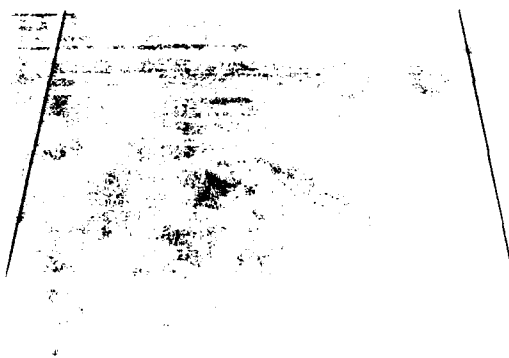
Photo 24. Mirafi 140 fabric section, NW-SE runway



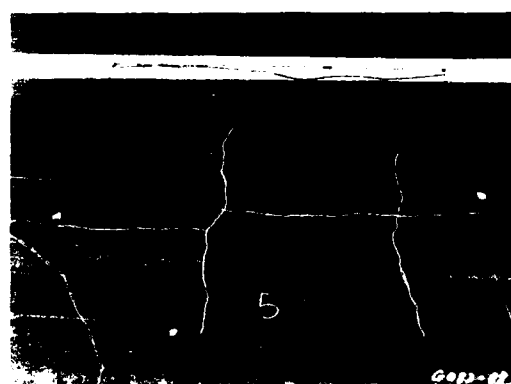
April 1977



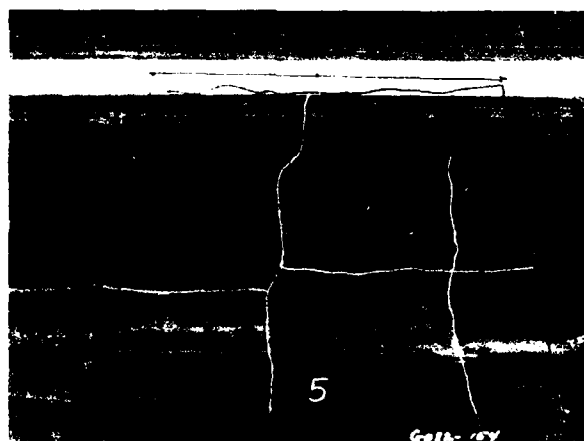
August 1979



June 1978

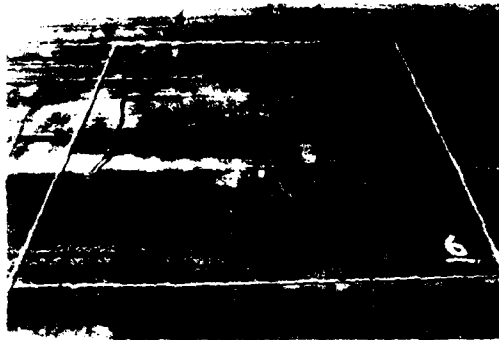


June 1980



June 1981

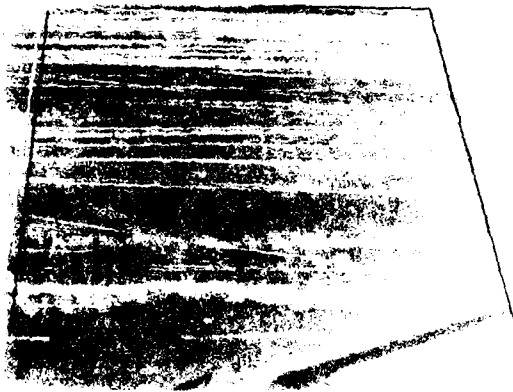
Photo 25. Control section, NW-SE runway-station 25+50 to 27+50



April 1977



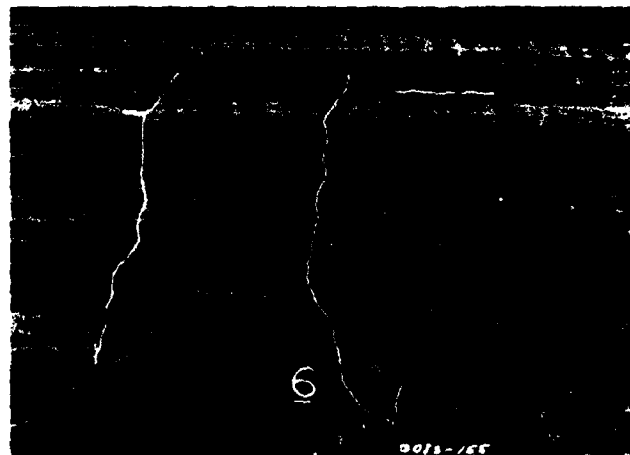
August 1979



June 1978

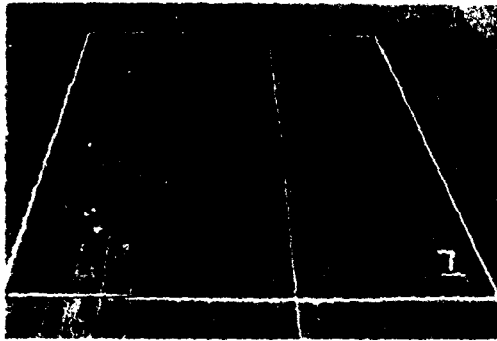


June 1980

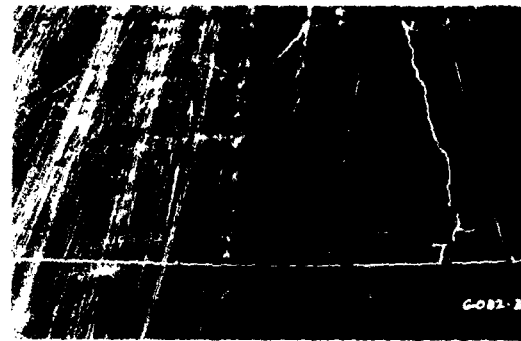


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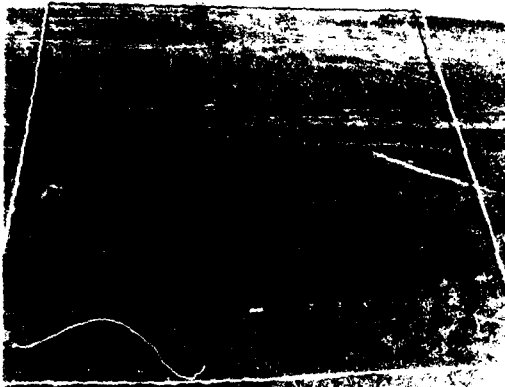
Photo 26. Sahuaro rubber section, NW-SE runway



April 1977



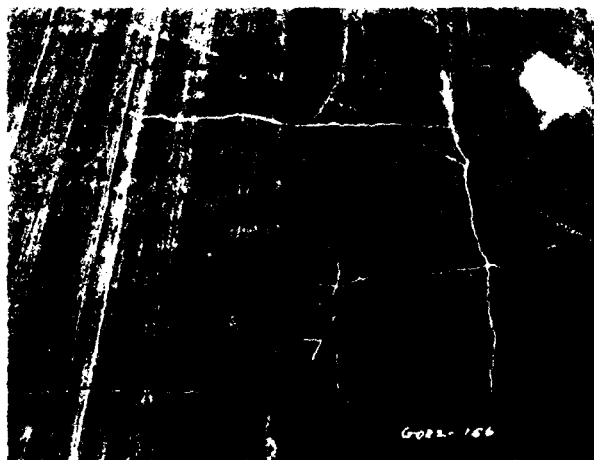
August 1979



June 1978

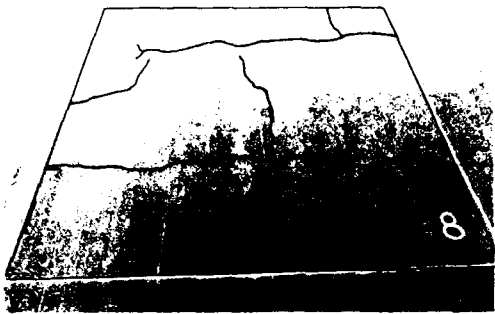


June 1980

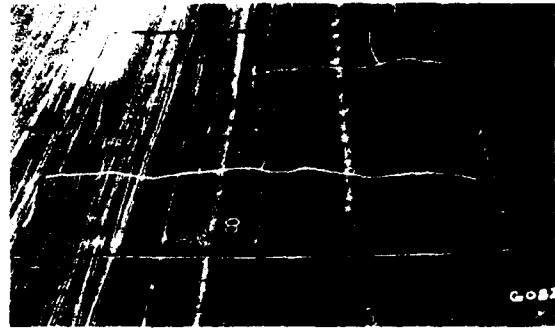


June 1981

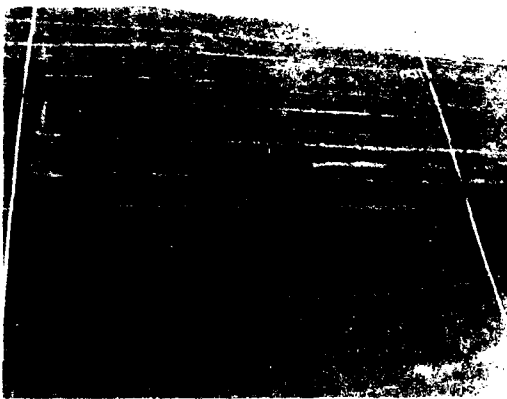
Photo 27. Sahuaro rubber section, N-S runway



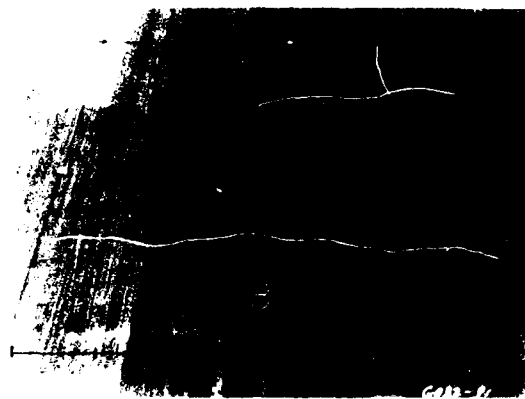
April 1977



August 1979



June 1978



June 1980

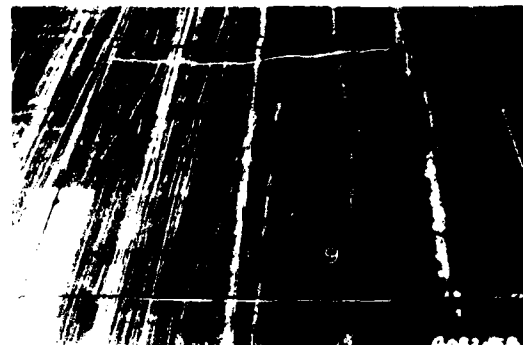


June 1981

Photo 28. Control section (south), N-S runway



April 1977



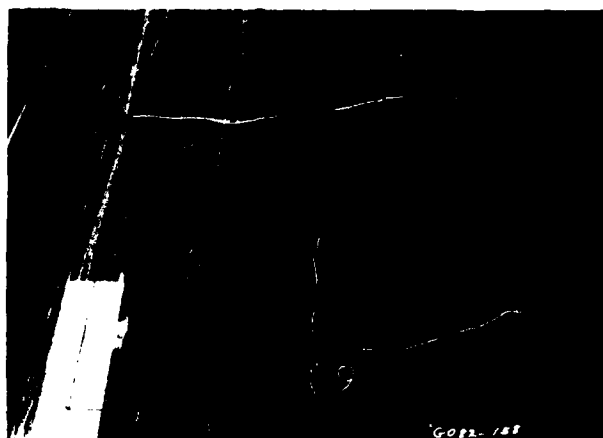
August 1979



June 1978

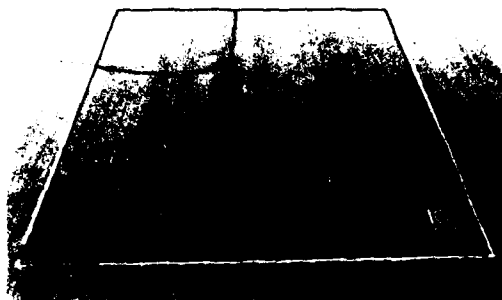


June 1980

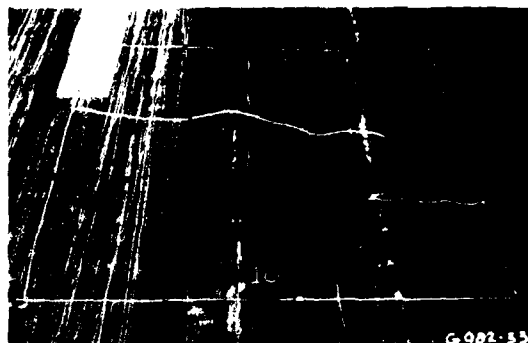


June 1981

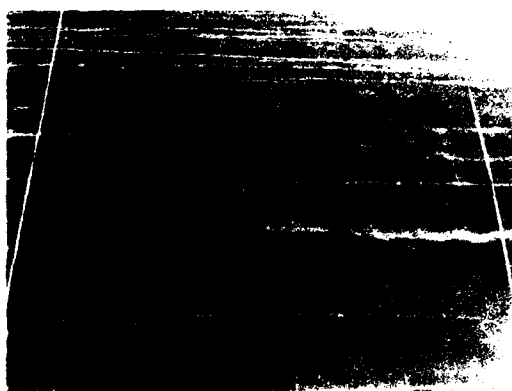
Photo 29. Bidim C-22 fabric section, N-S runway



April 1977



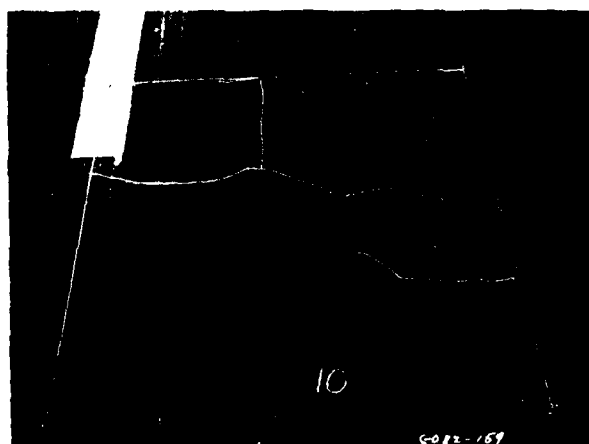
August 1979



June 1978

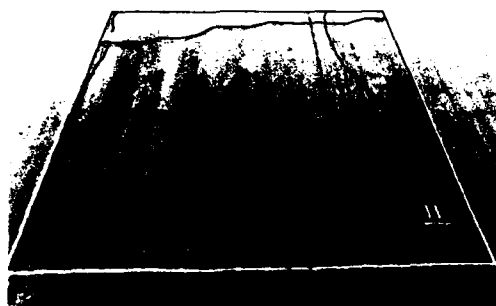


June 1980

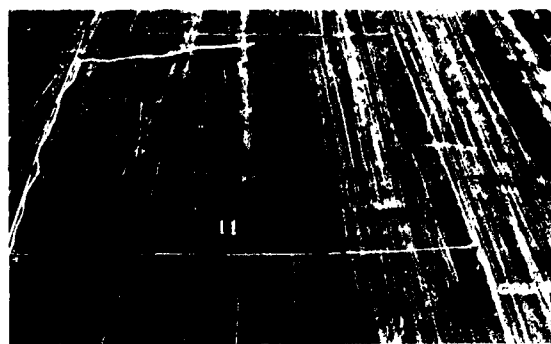


June 1981

Photo 30. Mirafi 140 fabric section, N-S runway



April 1977



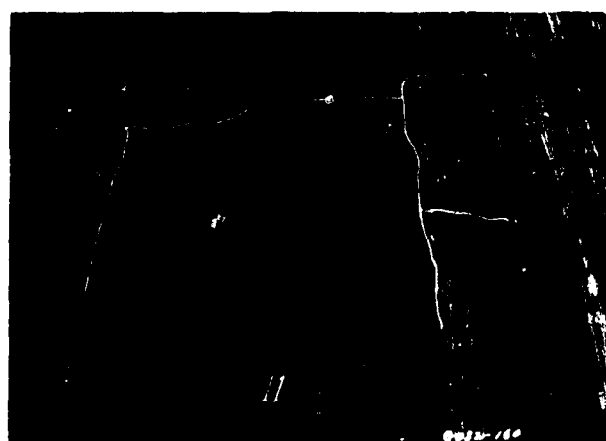
August 1979



June 1978



June 1980

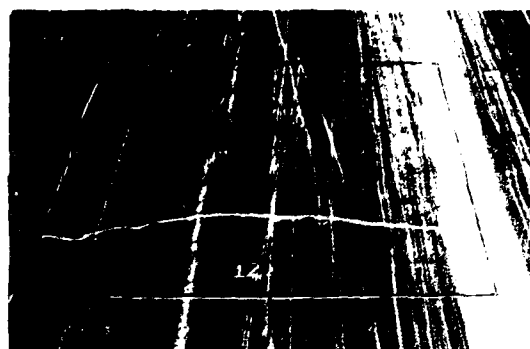


June 1981

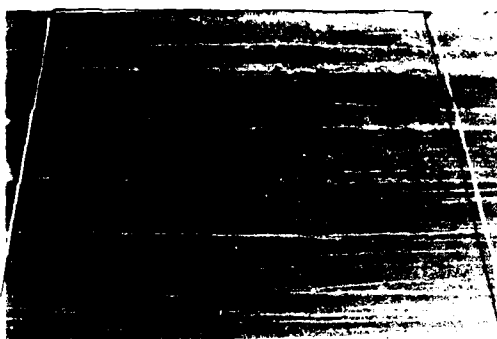
Photo 31. U. S. Rubber section, N-S runway



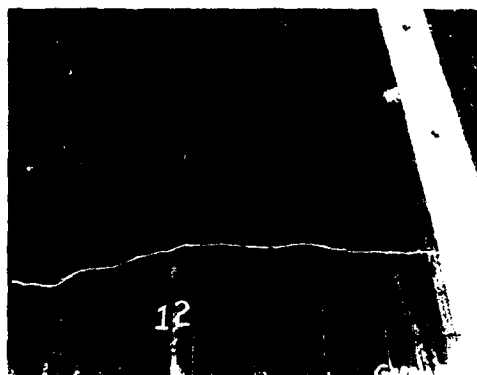
April 1977



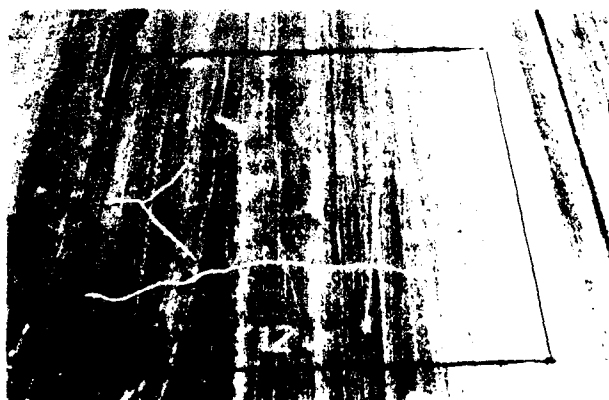
August 1979



June 1978

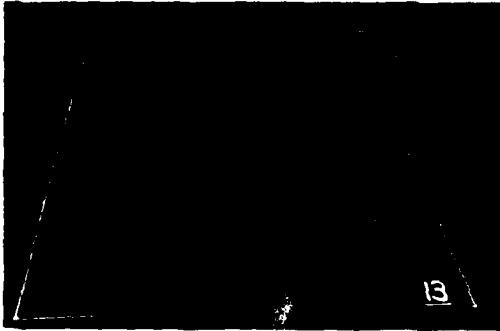


June 1980



June 1981

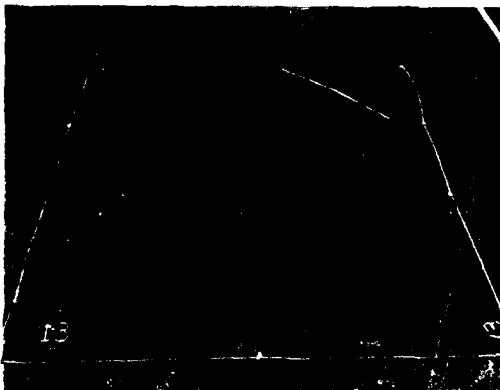
Photo 32. Control section (north), N-S runway



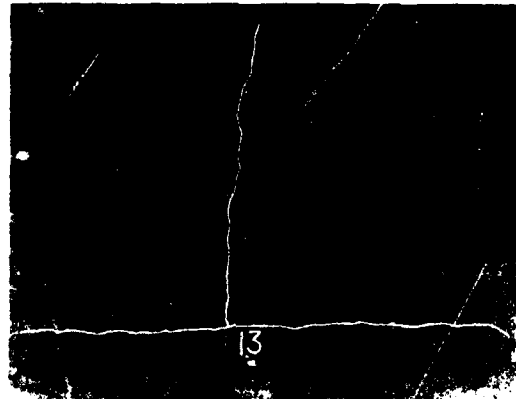
April 1977



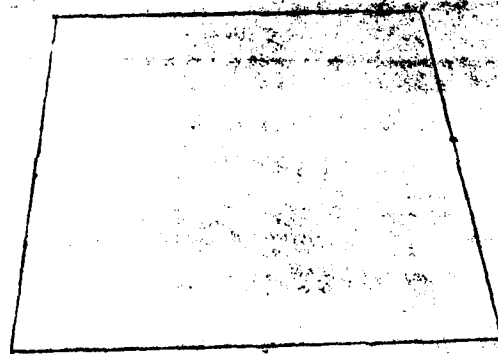
August 1979



June 1978



June 1980



June 1981

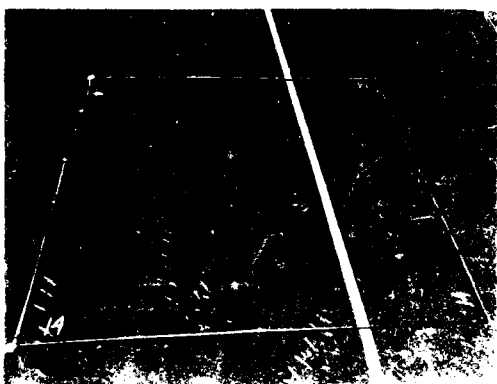
Photo 33. Bidim C-22 fabric section, apron



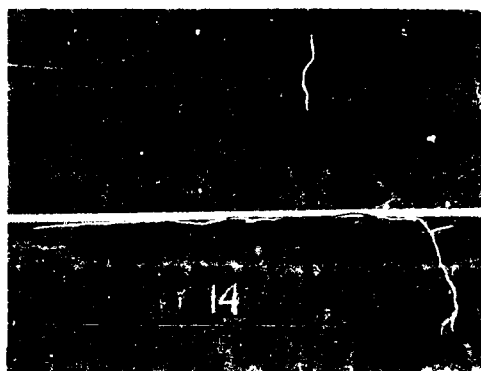
April 1977



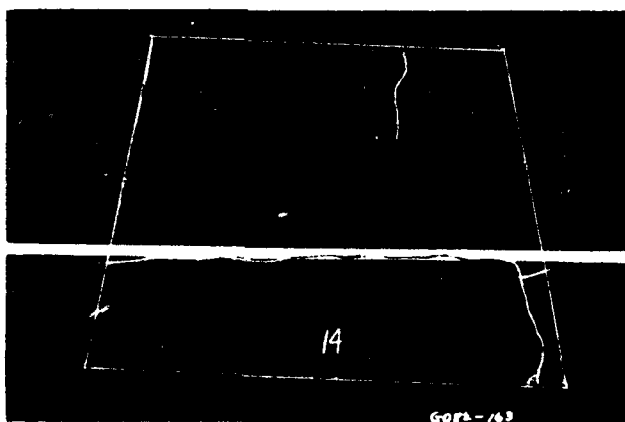
August 1979



June 1978

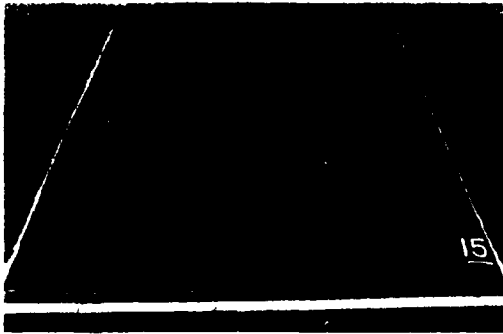


June 1980



June 1981

Photo 34. Mirafi 140 fabric section, apron



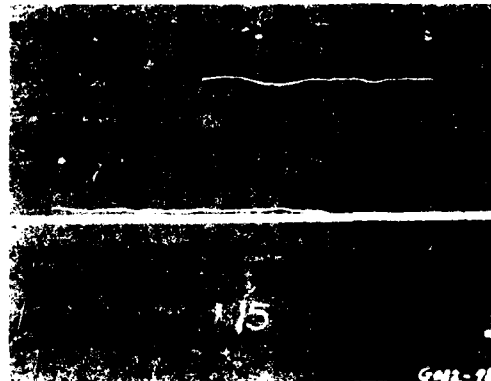
April 1977



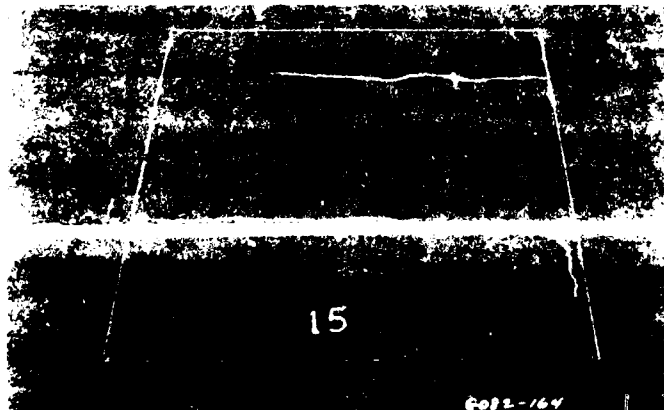
August 1979



June 1978

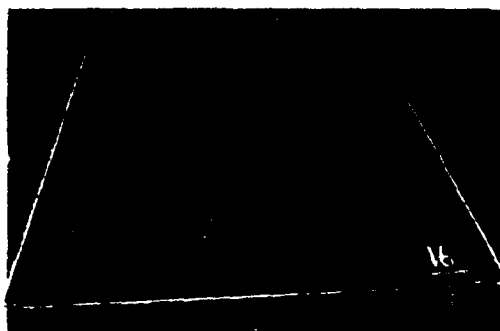


June 1980



June 1981

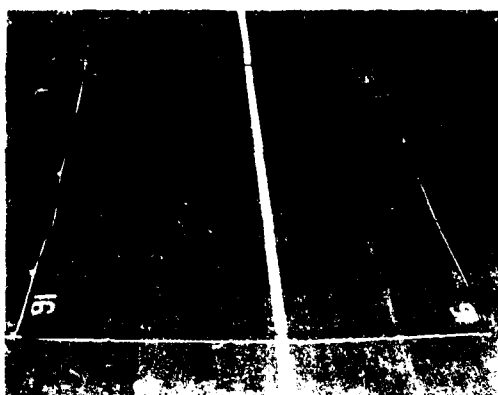
Photo 35. Sahuaro rubber section, apron



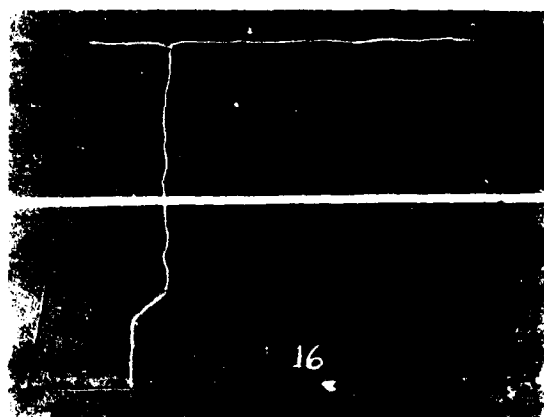
April 1977



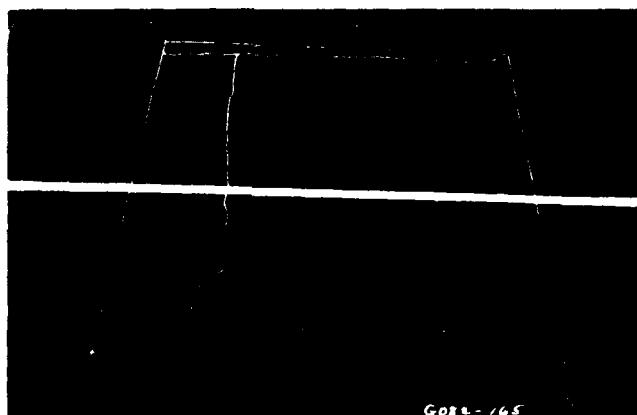
August 1979



June 1978

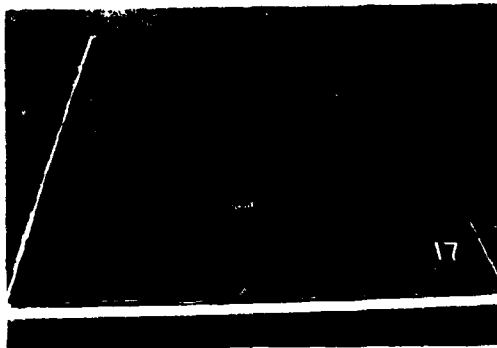


June 1980

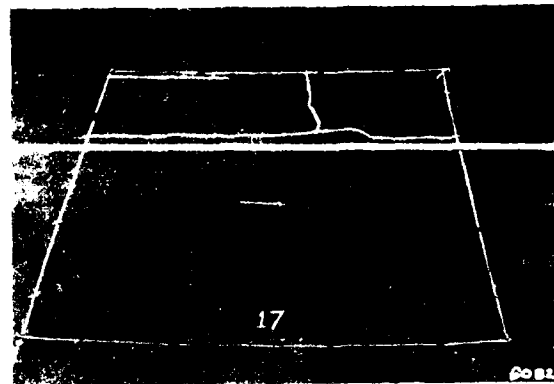


June 1981

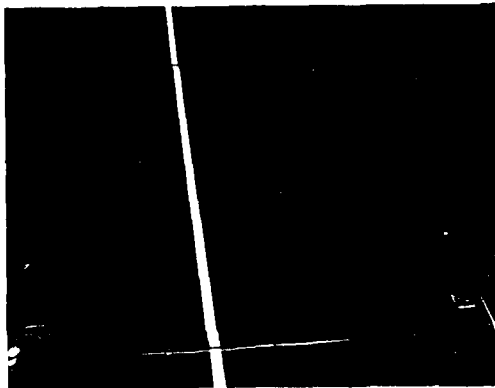
Photo 36. U. S. Rubber section, apron



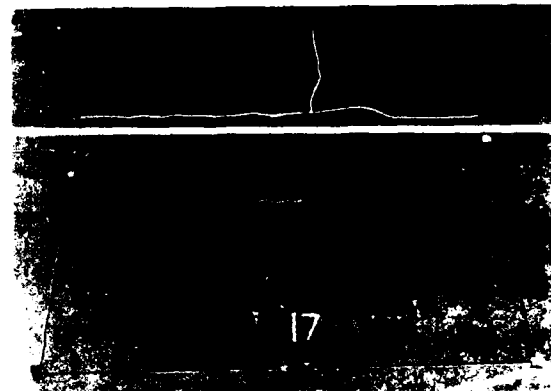
April 1977



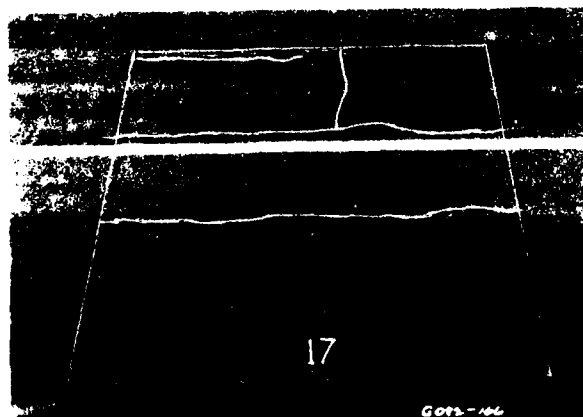
August 1979



June 1978



June 1980

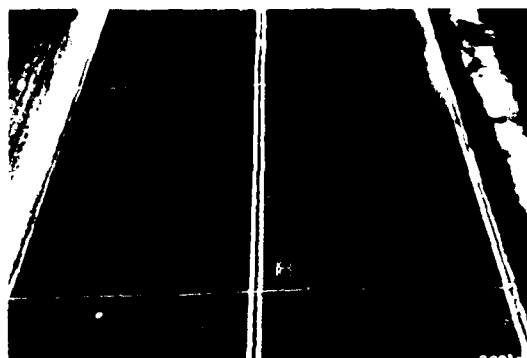


June 1981

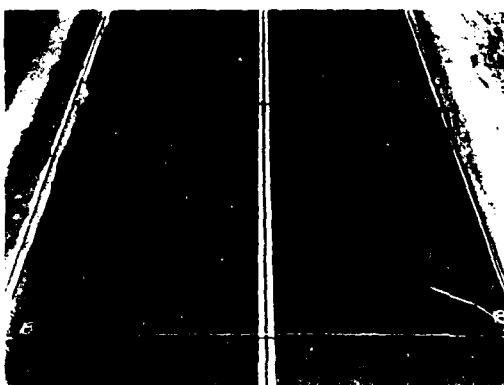
Photo 37. Control section, apron



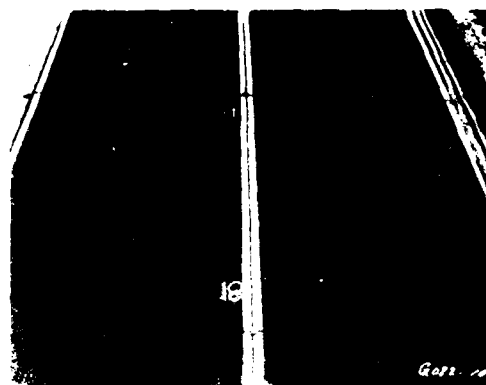
April 1977



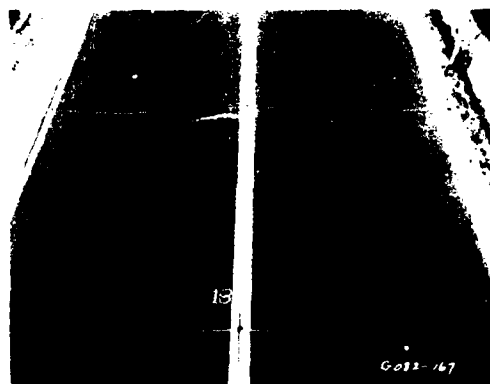
August 1979



June 1978

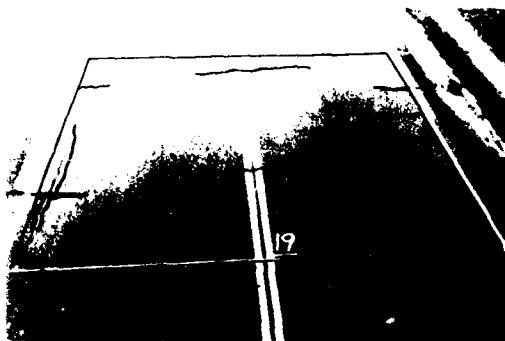


June 1980

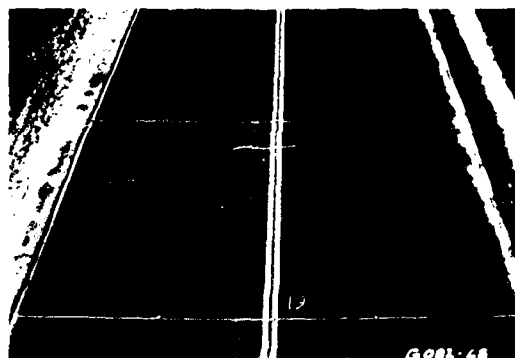


June 1981

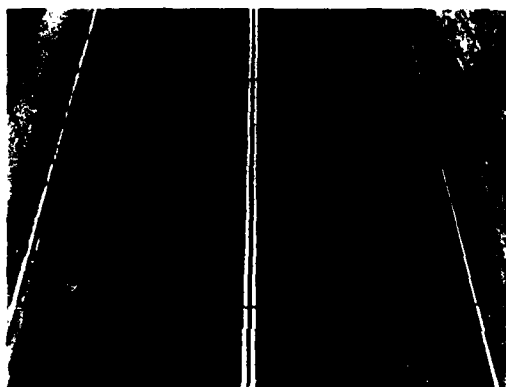
Photo 38. Sahuaro rubber section, Barnum Road



April 1977



August 1979



June 1978

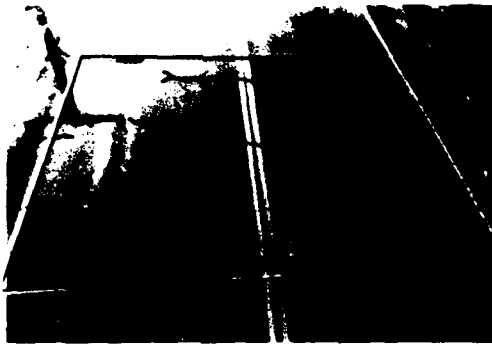


June 1980

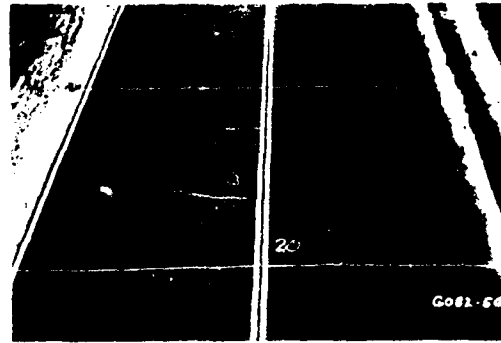


June 1981

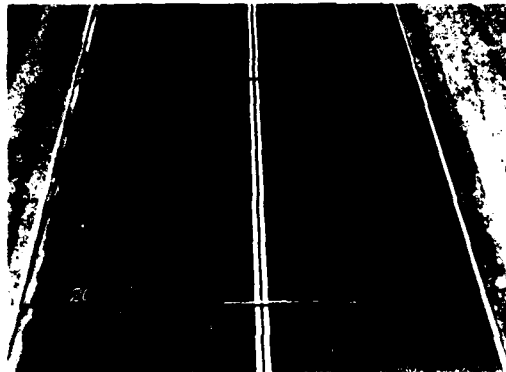
Photo 39. U. S. Rubber section, Barnum Road



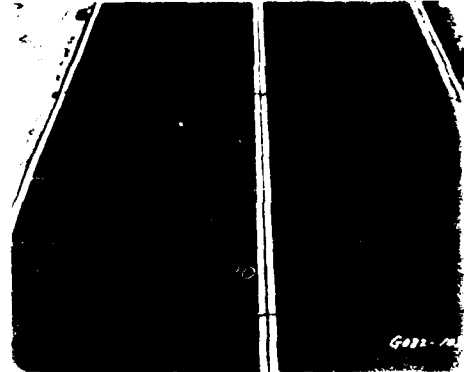
April 1977



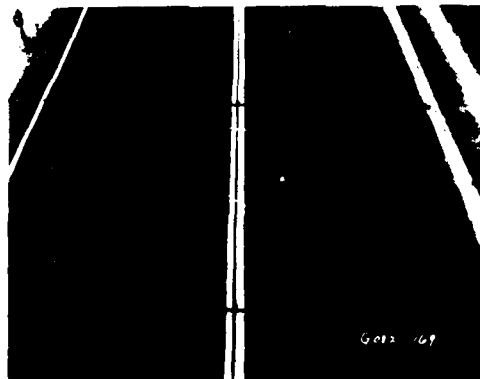
August 1979



June 1978

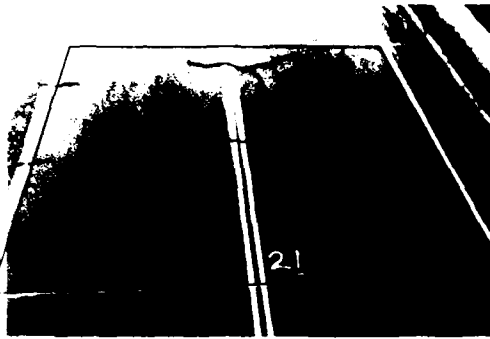


June 1980

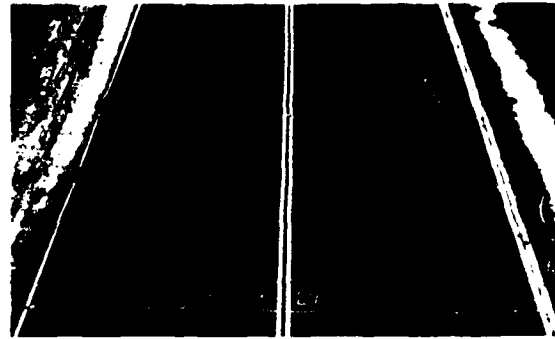


June 1981

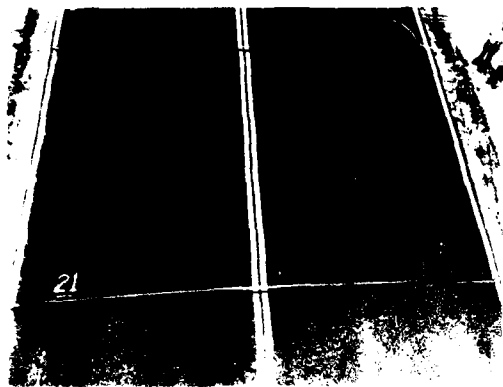
Photo 40. Mirafi 140 fabric section, Barnum Road



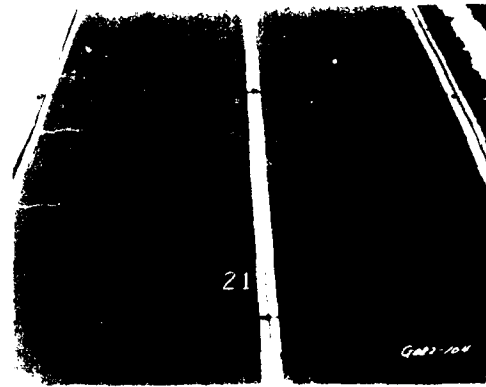
April 1977



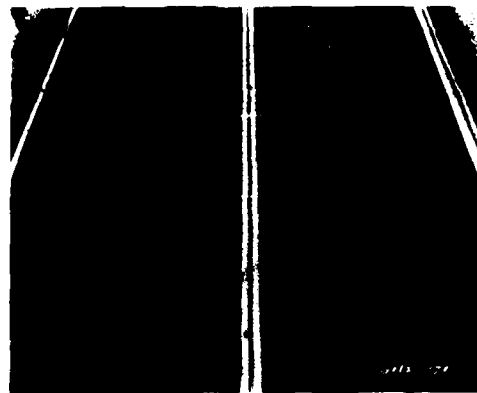
August 1979



June 1978

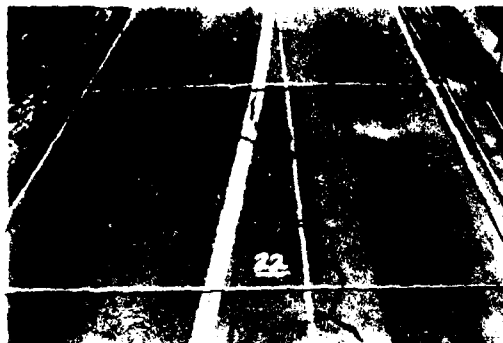


June 1980

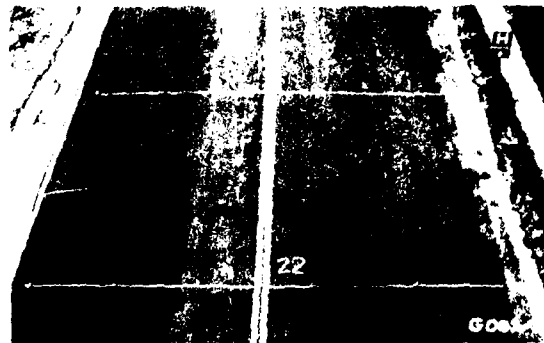


June 1981

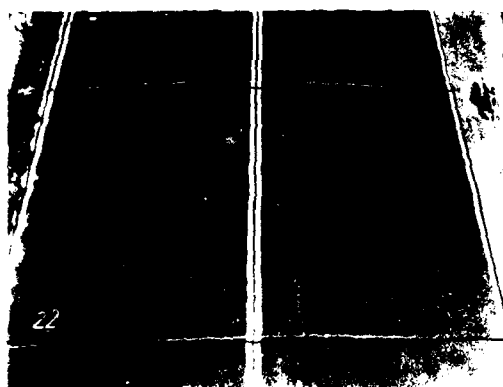
Photo 41. Bidim C-22 fabric section, Barnum Road



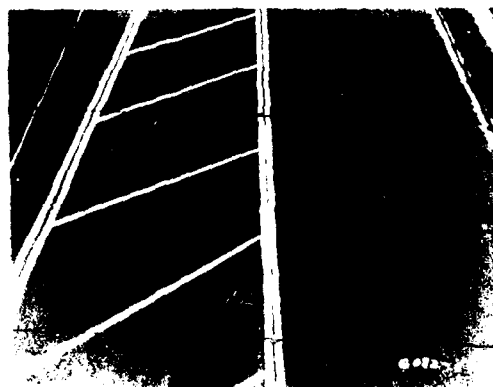
April 1977



August 1979



June 1978



June 1980



June 1981

Photo 42. Control section, Barnum Road

PART IV: FORT STEWART, GEORGIA

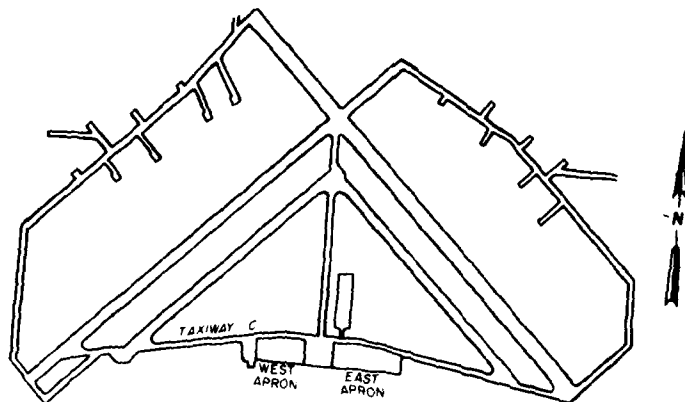
Test Locations

18. Figure 3 shows a layout of the test locations on the west apron of Wright AAF. Each fabric and asphalt-rubber test section measured 100 by 250 ft and was overlaid with a 1-1/2-in. of asphaltic concrete. The control section was approximately 120 by 220 ft and consisted of a keystone course overlaid with 1-1/2-in. of asphaltic concrete. A keystone* course has been used for a number of years at Fort Stewart as a means of minimizing reflection cracking and is now used as a standard with overlays at that post. The test areas were placed at Fort Stewart during the period 19-31 October 1977. The weather was clear and sunny with the temperature between 65° and 75°F. A tar emulsion slurry seal was placed over the apron surface in March 1978.

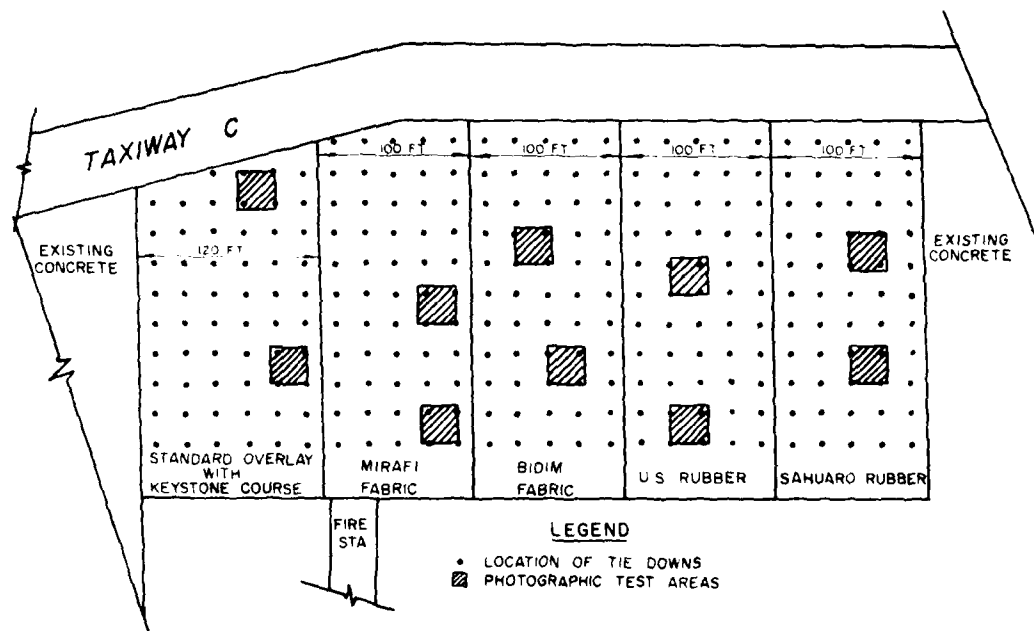
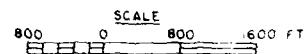
Performance and Analysis of Test Materials

19. The cracking pattern in the pavement surface on the west apron was typical reflection cracking from a soil-cement base course. The cracks had not been sealed and were about 1/4 to 1/2 in. wide. As shown in Figure 3 there were 10 test sections, two for each type of material. Photos 43 through 52 indicate the crack pattern that existed in the selected photographic areas before placement of the test materials and the progression of reflection cracking through the materials at the end of the last inspection in June 1981. Table 4 summarizes the percentage of cracking that has reflected over the 4-year period. The early cracking in the Mirafi 140 fabric test sections occurred within days after the rolling of the asphaltic overlay. It was felt at the time that the fabric had slipped on an uncured emulsion during rolling operations. Cores taken in the pavement indicated the cracks

* Single-surface treatment with uniform size aggregate (95-100 percent passing 1-in. sieve, 25-60 percent passing 1/2-in. sieve, and 0-5 percent passing No. 8 sieve).



GENERAL LOCATION MAP



LEGEND

- LOCATION OF TIE DOWNS
- ▨ PHOTOGRAPHIC TEST AREAS

WEST APRON

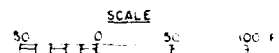


Figure 3. Location of test areas, Fort Stewart, Georgia

were the result of reflection from cracks in the underlying pavement. As noted in Table 4, the Sahuaro rubber section indicated the lowest crack reflection at 1.0 percent, and the Mirafi 140 fabric the highest at 56.9 percent. The existence of the tar slurry seal on the surface made it difficult to determine whether a fine hairline crack was a reflection crack or not. The tar seal has a characteristic of having numerous fine hairline cracks in a chicken wire pattern. The east apron was overlaid in 1976 using a keystone course with the 1-1/2 in. of asphaltic concrete, and it was noted during the inspection in June 1981 that reflection cracks are beginning to appear in the pavement surface of the east apron.

Table 4

Summary of Performance of Test Sections at Fort Stewart

Section No.	Test Material	Original Length of Cracks, ft	Percent of Cracks Reflected				Section Average
			May 1978	August 1979	April 1980	June 1981	
1	Sahuaro	101.8	0	0	0	2.0	1.0
2	Sahuaro	108.0	0	0	0	0	
3	U. S. Rubber	132.0	0	0	13.6	30.9	31.0
4	U. S. Rubber	145.0	0	16.4	31.3	31.3	
5	Bidim	126.0	0	5.0	16.3	24.3	42.6
6	Bidim	132.0	0	26.5	35.8	60.8	
7	Mirafi	138.0	29.7	37.0	48.6	63.1	56.9
8	Mirafi	120.0	8.3	19.9	33.6	50.7	
9	Control	131.9	0	0	0	0	9.1
10	Control	99.0	0	0	0	18.1	



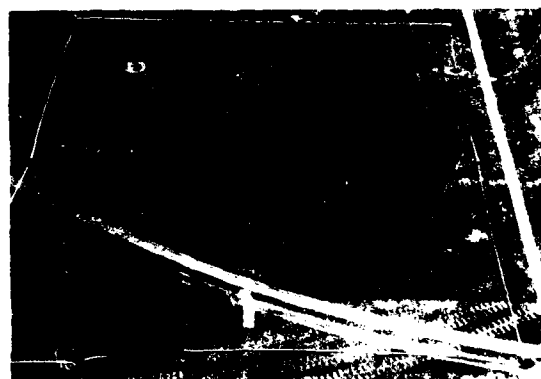
June 1977



August 1979



May 1978

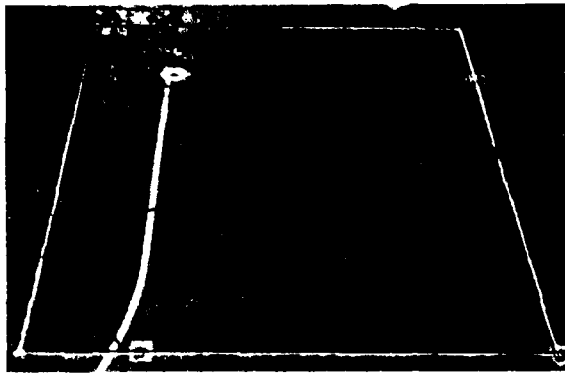


April 1980

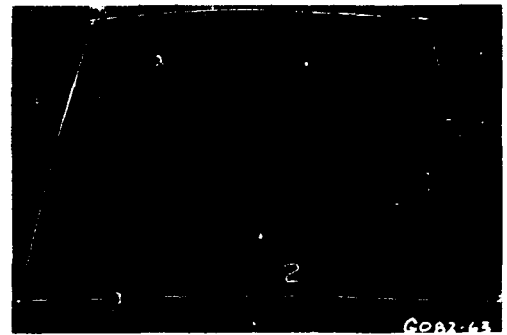


June 1981

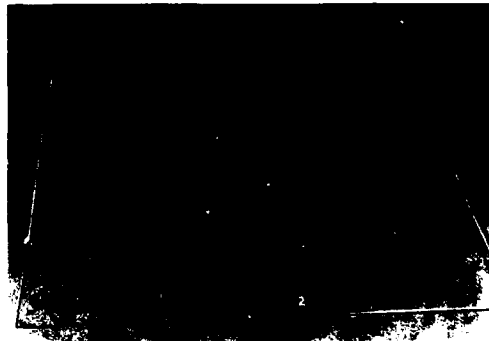
Photo 43. Sahuaro rubber section, south end of west apron



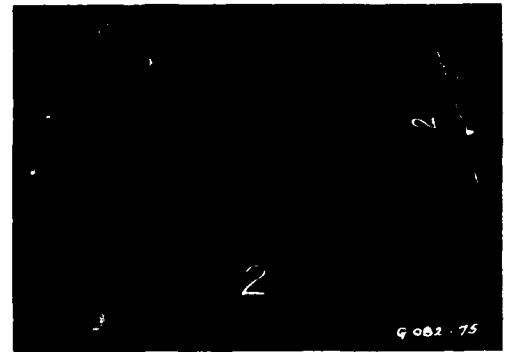
June 1977



August 1979



May 1978

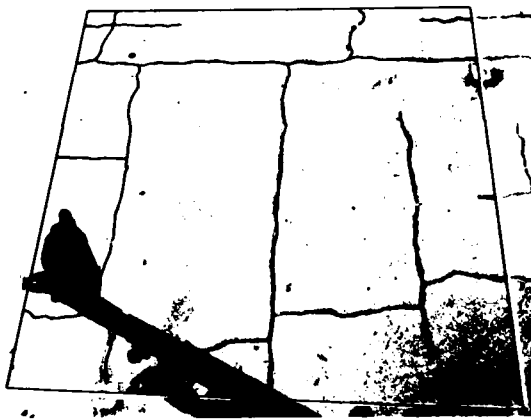


April 1980

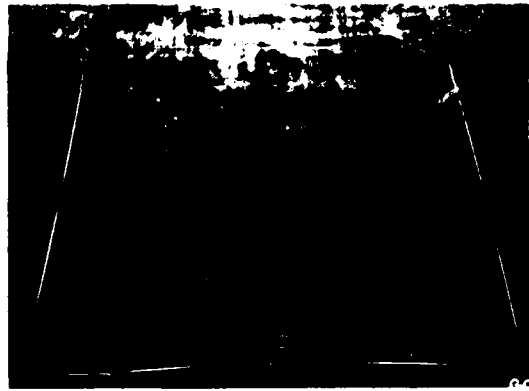


June 1981

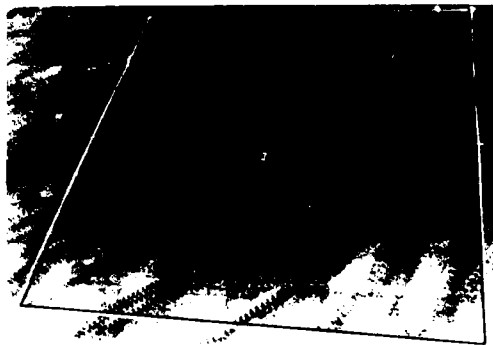
Photo 44. Sahuaro rubber section, north end of west apron



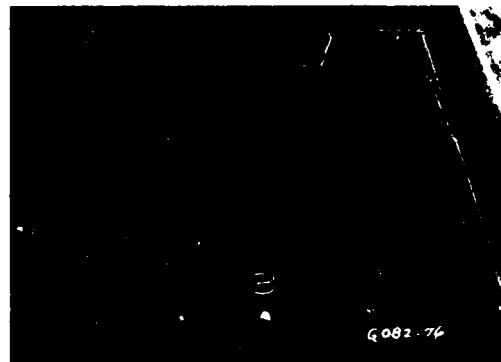
June 1977



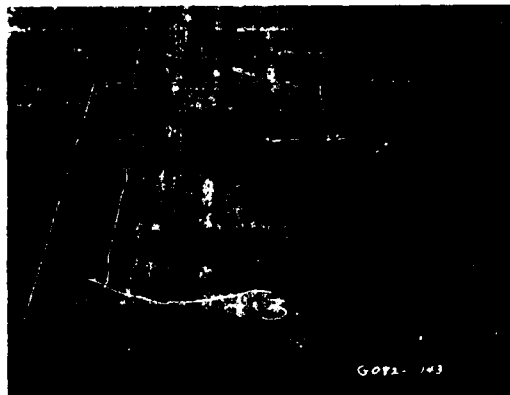
August 1979



May 1978



April 1980

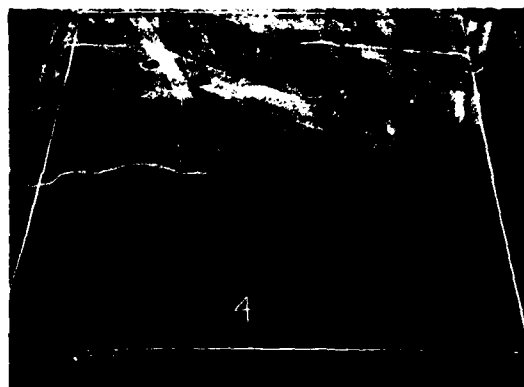


June 1981

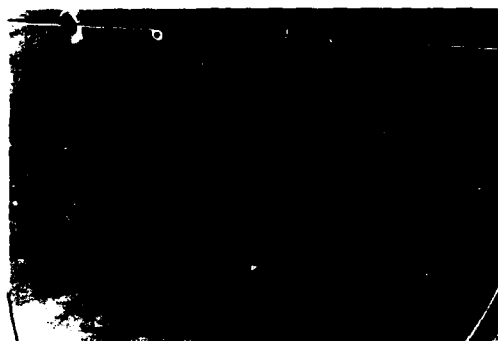
Photo 45. U. S. Rubber section, south end of west apron



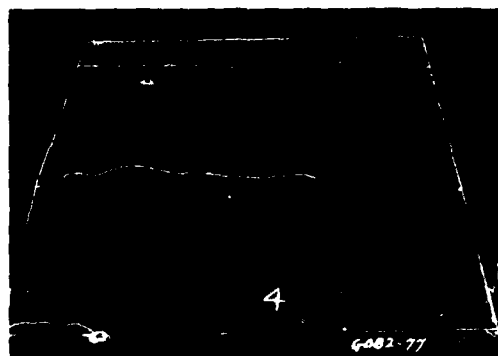
June 1977



August 1979



May 1978

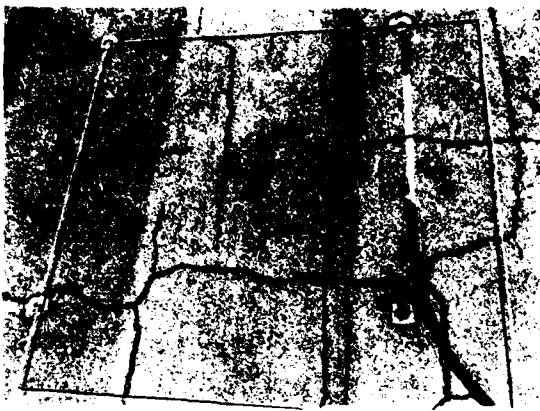


April 1980



June 1981

Photo 46. U. S. Rubber section, north end of west apron



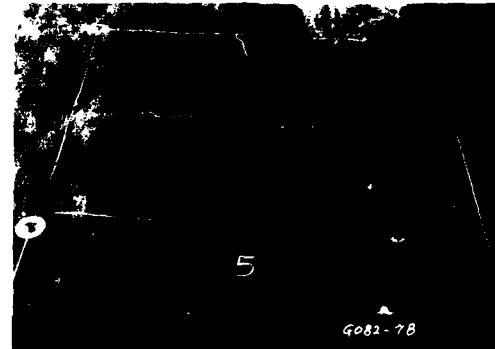
June 1977



August 1979



May 1978



April 1980

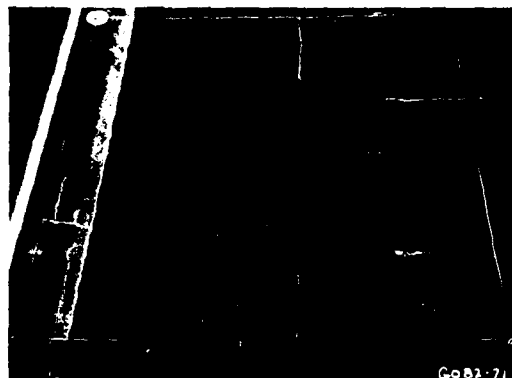


June 1981

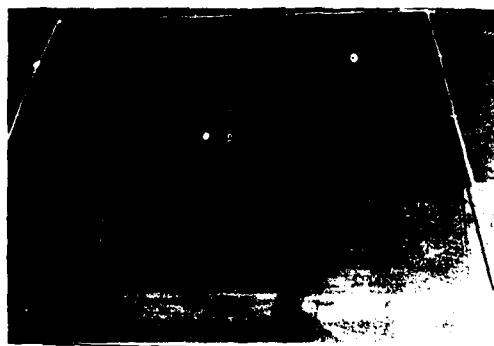
Photo 47. Bidim C-22 fabric section, north end of west apron



June 1977



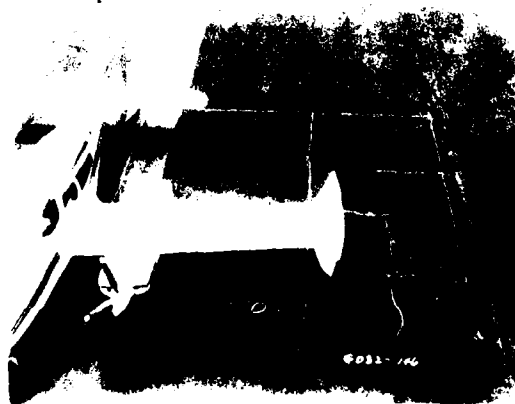
August 1979



May 1978

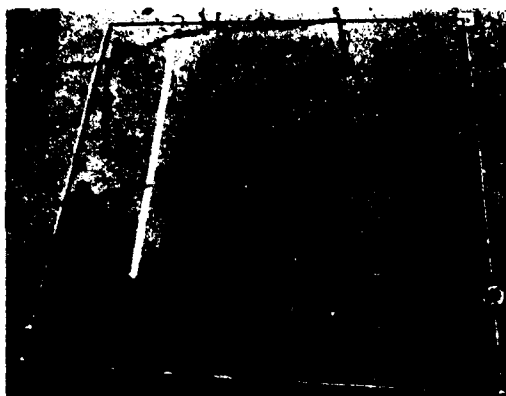


April 1980

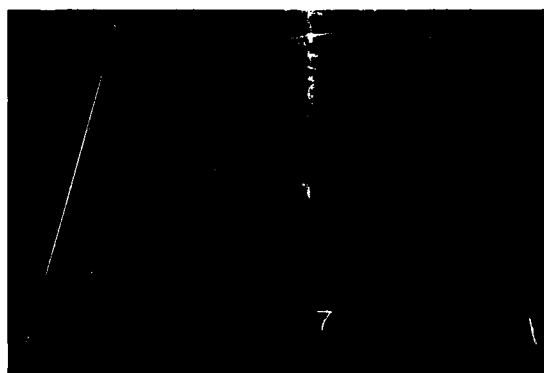


June 1981

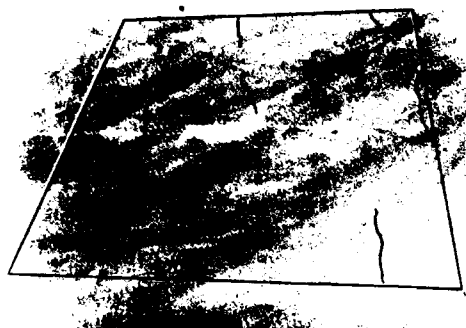
Photo 48. Bidim C-22 fabric section, south end of west apron



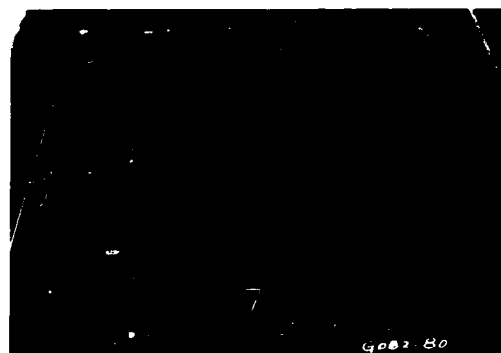
June 1977



August 1979



May 1978

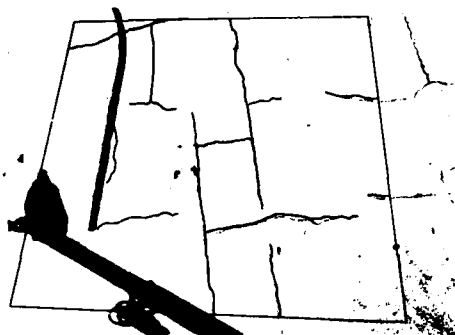


April 1980



June 1981

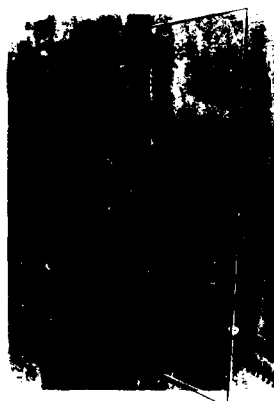
Photo 49. Mirafi 140 fabric section, south end of west apron



June 1977



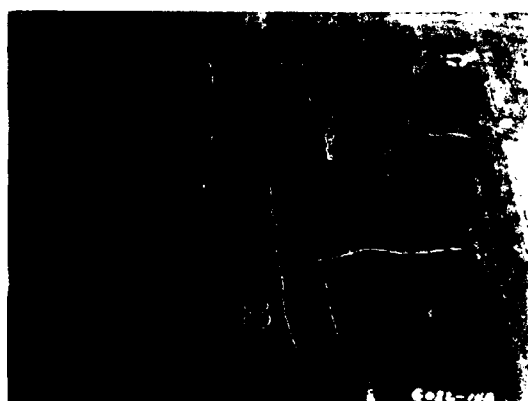
August 1979



May 1978



April 1980

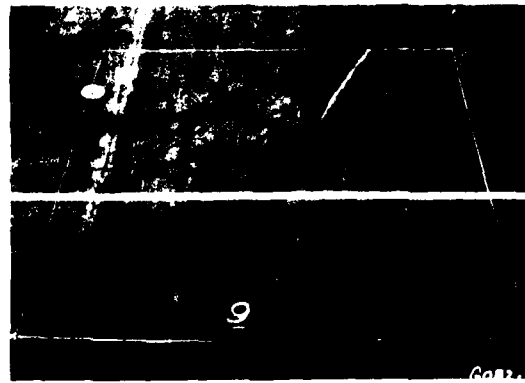


June 1981

Photo 50. Mirafi 140 fabric section, north end of west apron



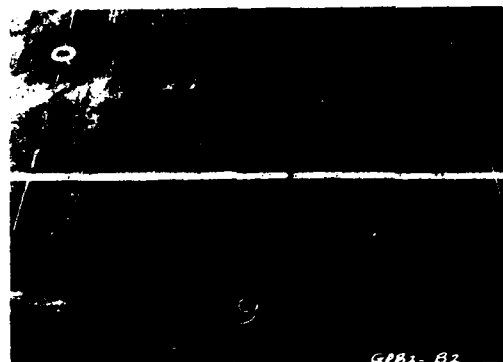
June 1977



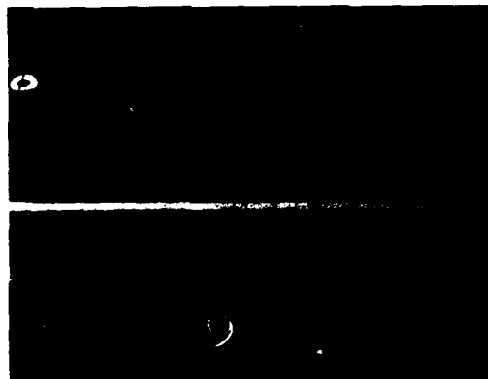
August 1979



May 1978

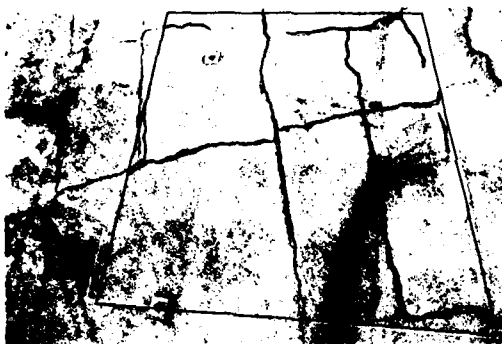


April 1980



June 1981

Photo 51. Control section, south end of west apron



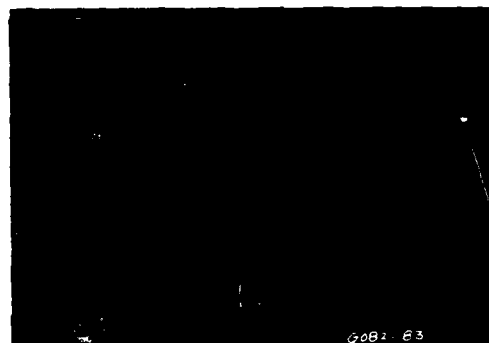
June 1977



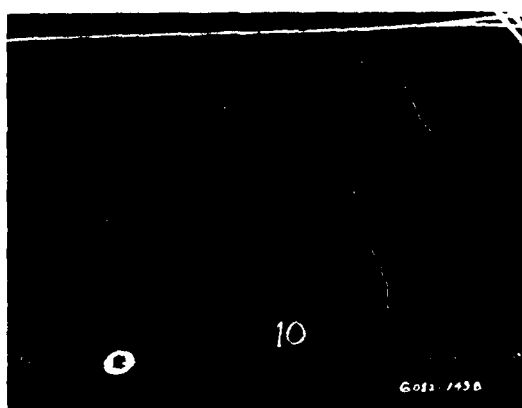
August 1979



May 1978



April 1980



June 1981

Photo 52. Control section, north end of west apron

PART V: FORT POLK, LOUISIANA

Test Location

20. Figure 4 shows a layout of Louisiana Avenue, the entrance road to Fort Polk, which was selected to receive a treatment of the Petromat fabric during the overlay of the road. From the entrance gate on Louisiana Avenue to Georgia Avenue, the fabric was placed on the roadway and shoulders before placement of a 1-1/2-in. asphaltic concrete overlay. The next block from Georgia Avenue to Texas Avenue received a 2-in. asphaltic concrete overlay without fabric. The original roadway was a 6-in. jointed portland cement concrete pavement, which was overlaid in 1962 with 2 in. of asphaltic concrete. The majority of the cracking in this pavement consists of the reflection of the joints from the underlying portland cement concrete. The fabric and overlay were placed on the main roadway in December 1977, and the shoulder pavements and fabric were placed in January 1978. The weather was quite cool and wet during the period of work.

Performance and Analysis of Test Material

21. As stated previously, the majority of the cracking in the pavements on Louisiana Avenue consisted of the reflection of the joints from the portland cement concrete. The selected test areas each contained two joints in the 25-ft-wide area. It was reported that the cracks from the joints were cleaned and sealed before placement of the fabric and overlay. Photo 53 shows a general view of the condition of the pavement surface in 1977 before the overlay. An inspection made in June 1978 indicated that two joint cracks in the selected test areas had reflected through the overlay. An inspection of the entire roadway at that time indicated that about 50 percent of the joint cracking had reflected through the overlay where the Petromat fabric was placed and about 10 percent reflection cracking had occurred in the area between Georgia and Texas Avenues. This area had received a 2-in. overlay

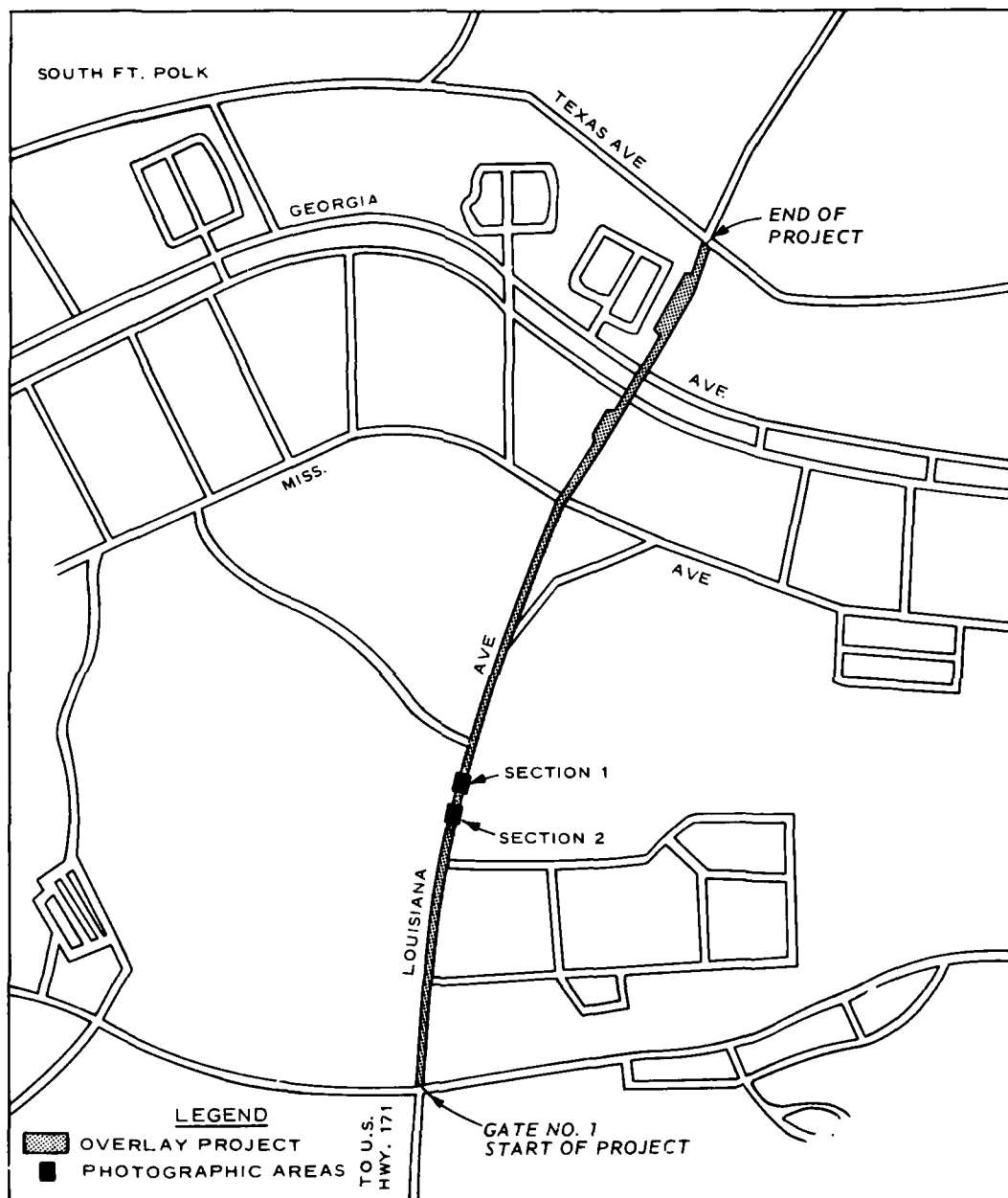
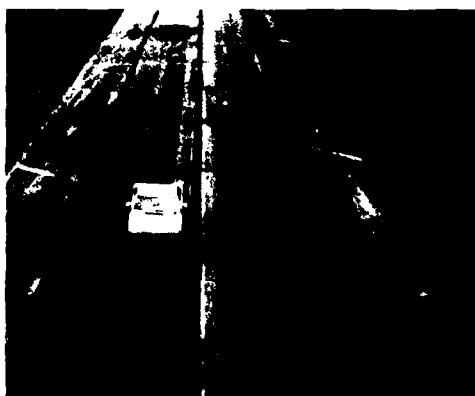


Figure 4. Location of test areas, Fort Polk, Louisiana

as compared with a 1-1/2-in. overlay where the fabric was placed. The sections were not inspected in 1979 or 1980. The inspection in June 1981 (Photo 53) indicated that 100 percent of the joint cracking had reflected in both the fabric area and the area where no fabric was used. Most of the cracks had been repaired and filled in 1980 in the area of the roadway where the Petromat fabric was used. However, the cracks in the 2-in. overlay section had not been repaired and sealed at this time, as noted in Photo 53.



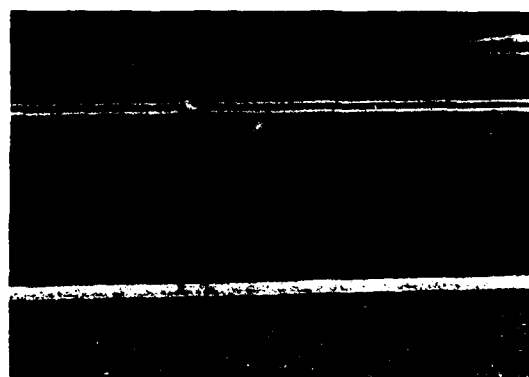
December 1977



June 1981 - fabric



June 1978



June 1981 - fabric



June 1981 - Control

Photo 53. Joint condition on Louisiana Avenue

PART VI: FORT CARSON, COLORADO

Test Locations

22. Figure 5 shows a layout of the test locations on Wilderness Road. As noted, the test sections of fabric and asphalt-rubber membrane are not located in one continuous test section but intermittent along the roadway. The test sections varied in length from 150 to 450 ft long and the width of the roadway. Each test area was overlaid with a 1-1/2-in. of asphaltic concrete, and the control section consisted of only the standard 1-1/2-in. overlay. The test areas were placed at Fort Carson during the period 12-14 July 1978. The pavement widening and gravel shoulder work was completed during the week of 3 July. The weather was sunny, and the temperature varied from 80° to 95°F during placement of the test items and overlay.

Performance of Test Materials

23. Wilderness Road is used frequently by trucks hauling explosives from the ammo storage area located adjacent to the road (Photo 54). The large trucks broke the pavement surface along the edges (Photo 55) and thus narrowed the width of the roadway to about 20 ft. The area between the white stripes (Photo 56) was essentially left intact during the repair work, and the edges were widened 2 ft on each side with gravel shoulders (Photo 57). As shown in Figure 5, there were 12 test sections, two for each type of material. Photos 58 through 69 indicate the crack pattern that existed in the selected photographic areas before placement of test materials and the progression of reflection cracking through these materials to the end of the last inspection in June 1981. These photographs also show that the alligator-type cracking along the edge of the roadway is the same condition as shown in Photo 56 that was left intact in the repair work. The initial length of cracking in each section was not measured before placement of the test materials.

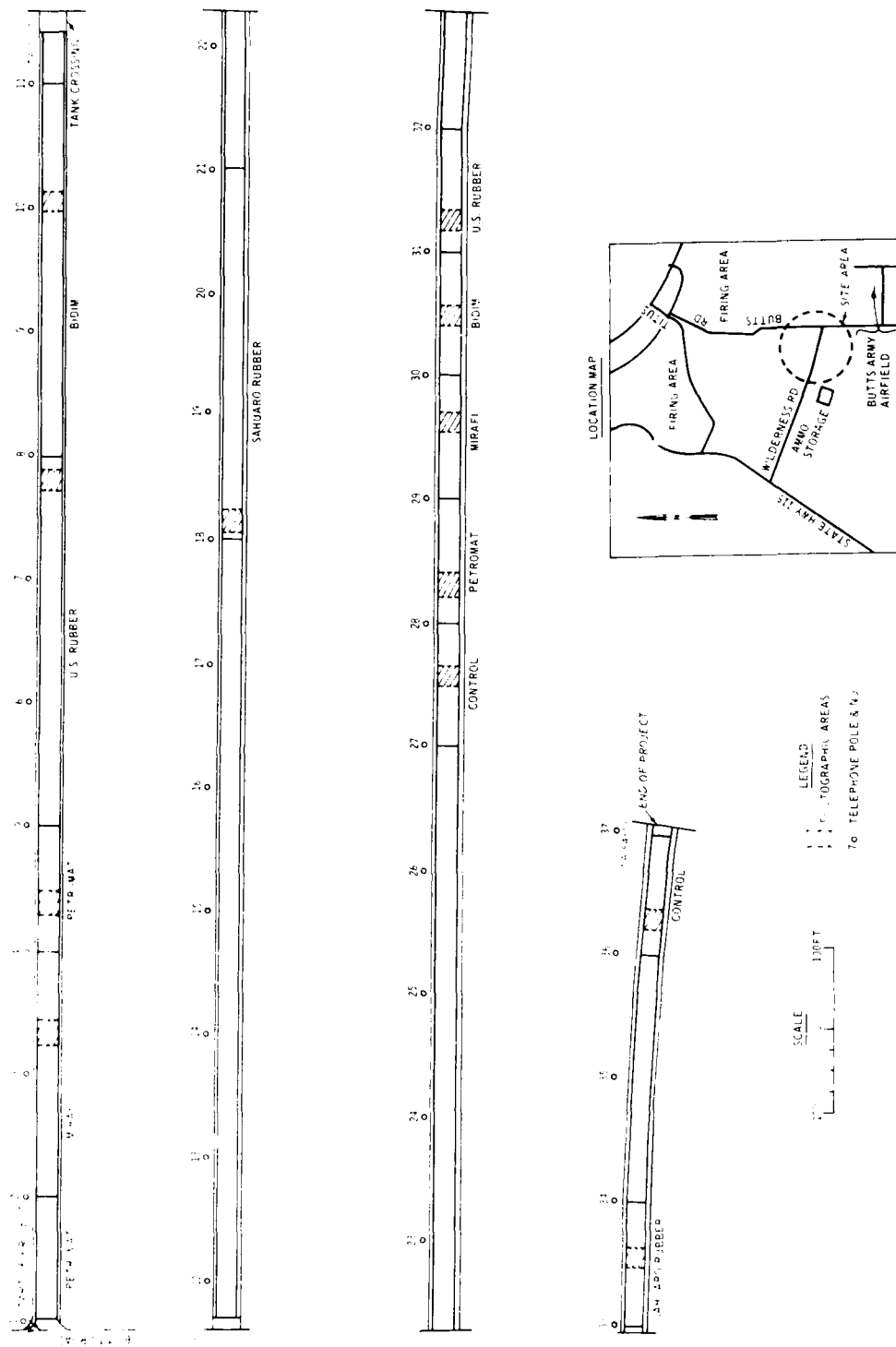


Figure 5. Location of test areas, Fort Carson, Colorado

Analysis of Findings

24. The test materials have been in place on Wilderness Road for a period of almost 3 years. As indicated in the photographs, not much crack reflection has occurred in any of the sections. The alligator-type cracking along the roadway edge is starting to reflect in most of the areas where this type of cracking was noted in the original survey. The alligator pattern of cracking usually indicates a structural deficiency in the pavement, and if this is the case, it is doubtful that the presence of the fabric or asphalt-rubber membrane will do much to correct the condition. Widening the roadway should keep the loads away from the pavement's edges and help to prevent the failures in this area.

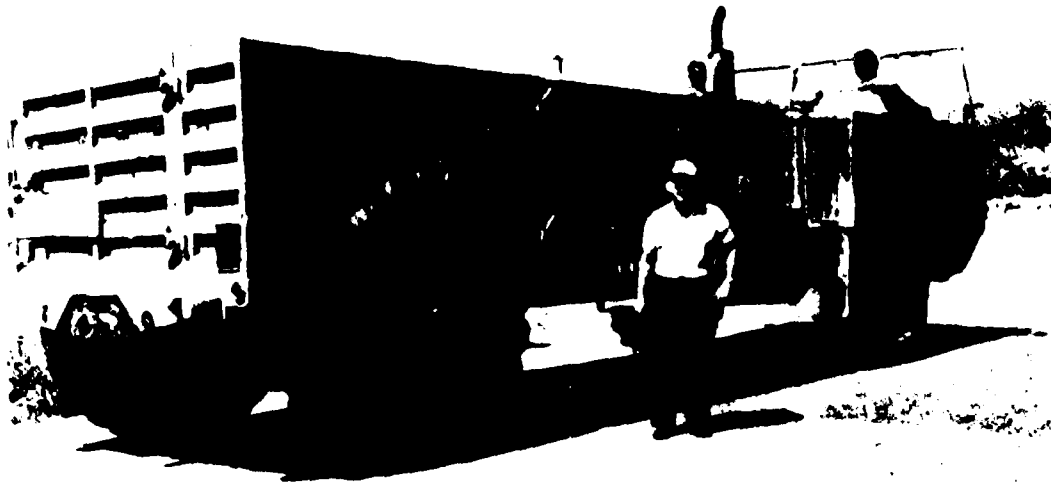


Photo 54. Vehicle used to haul explosives
from ammo storage area



Photo 55. Condition of Wilderness Road
before repair, May 1978

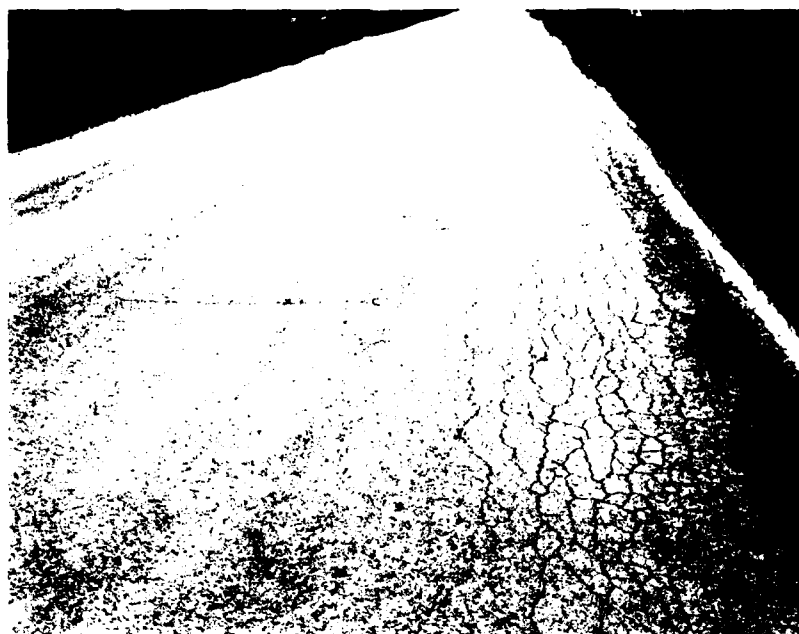


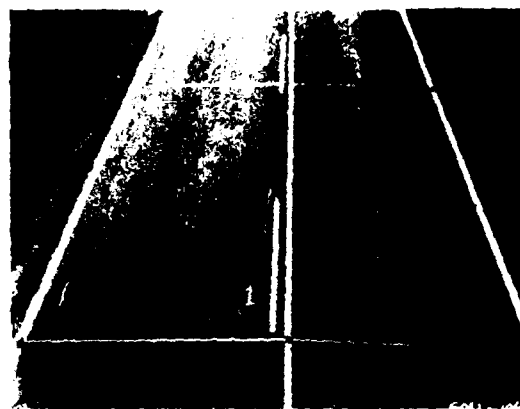
Photo 56. Road not repaired between
white stripes



Photo 57. Road widened 2 ft on each side for a
total width of 24 ft with gravel shoulders



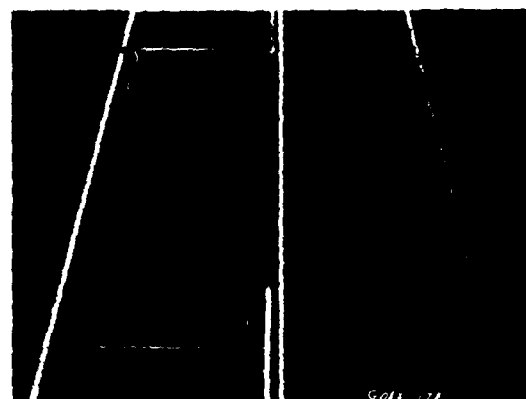
June 1978



August 1980

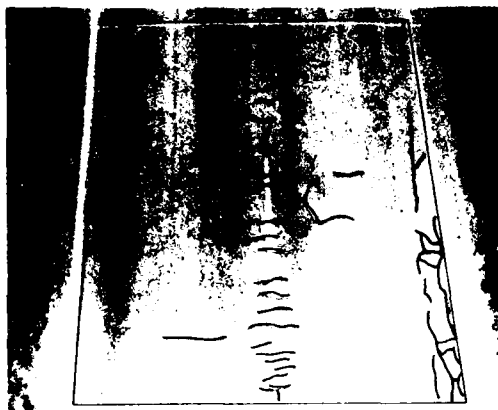


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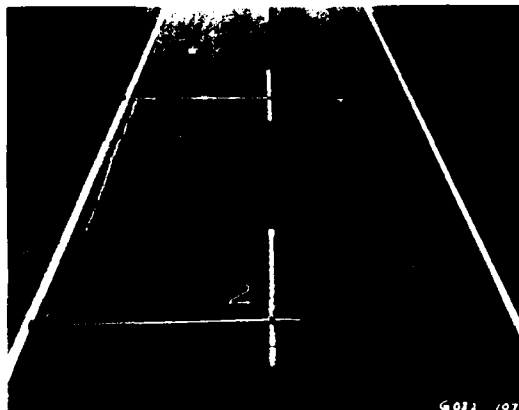


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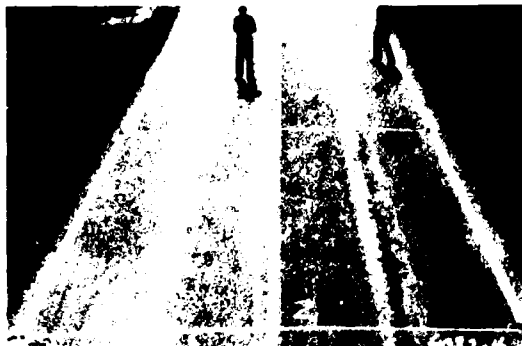
Photo 58. Mirafi 140 fabric section, south end of Wilderness Road



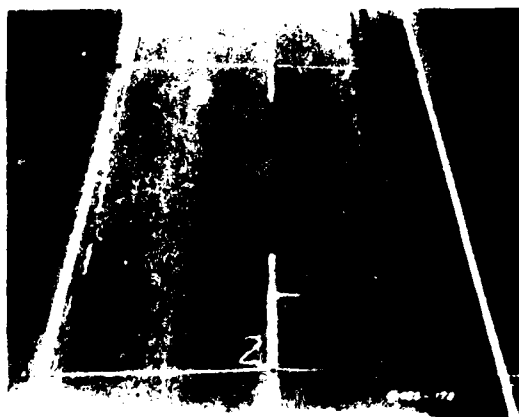
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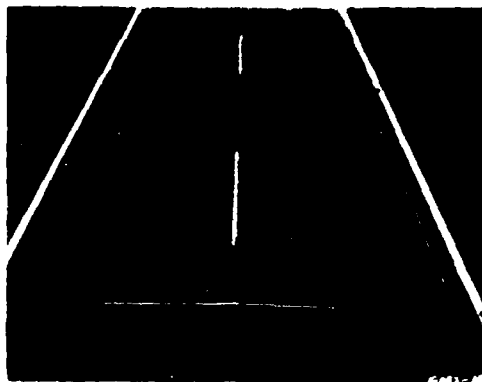


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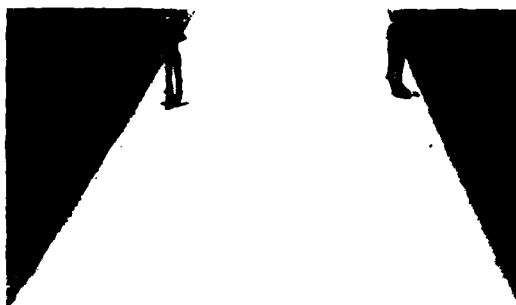
Photo 59. Petromat fabric section, south end of Wilderness Road



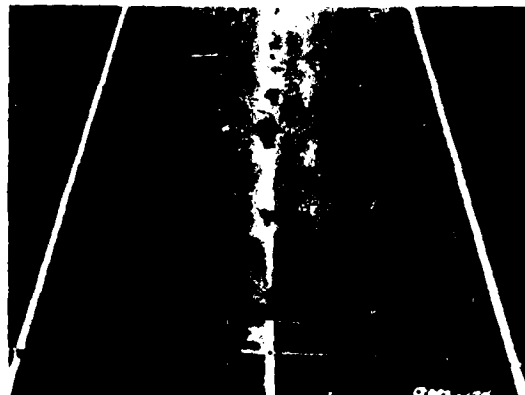
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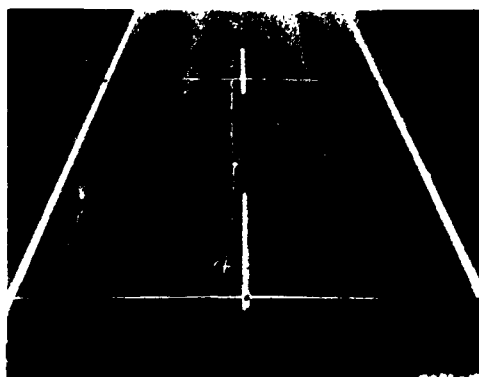


June 1981

Photo 60. U. S. Rubber section, south end of Wilderness Road



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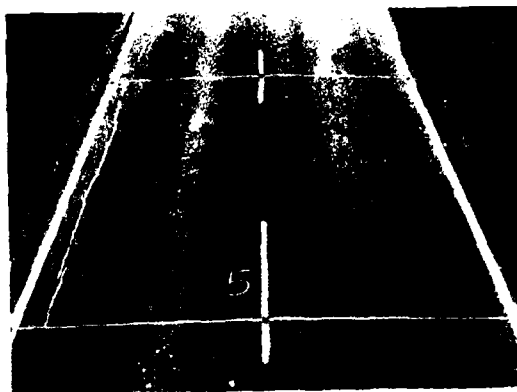


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Photo 61. Bidim C-22 fabric section, south end of Wilderness Road



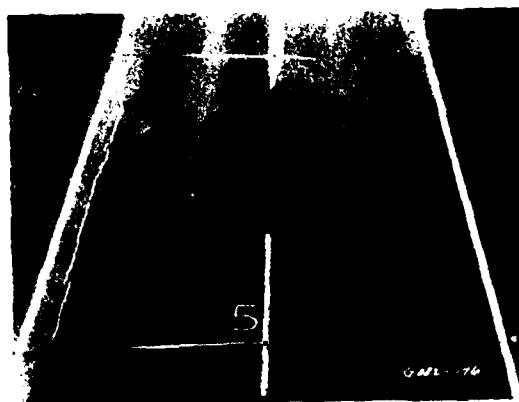
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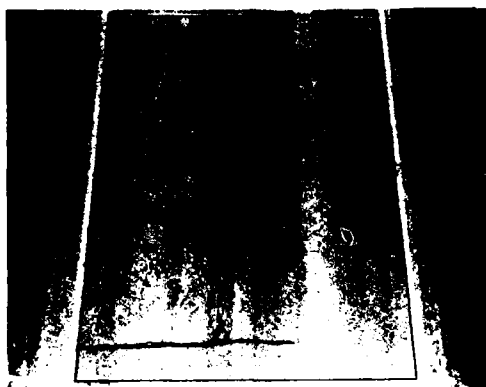


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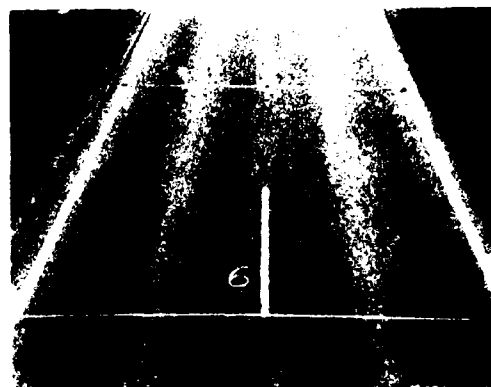


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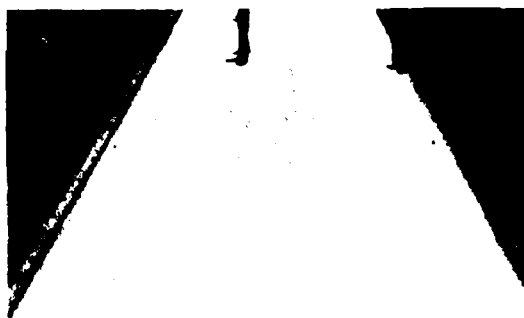
Photo 62. Sahuaro rubber section, south end of Wilderness Road



June 1978



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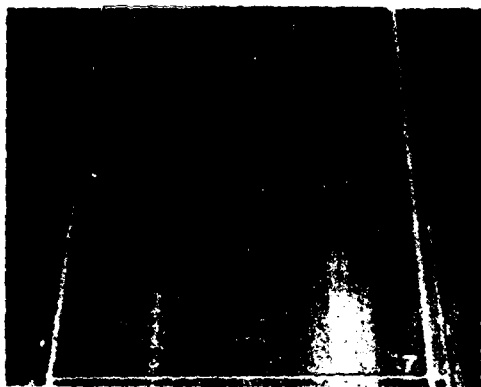


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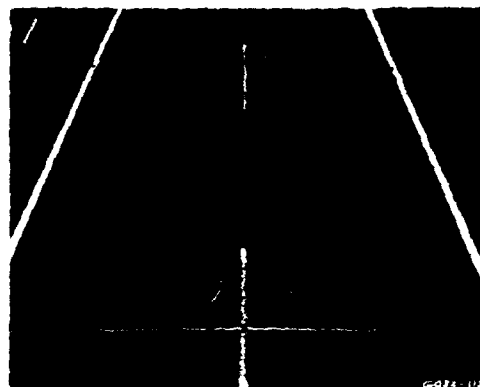


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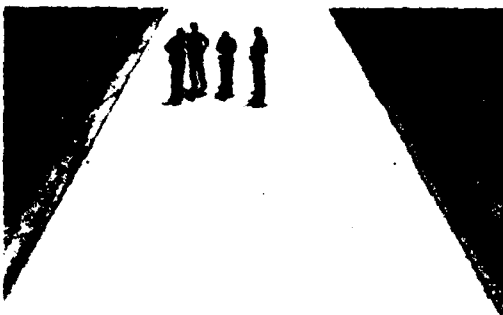
Photo 63. Control section, south end of Wilderness Road



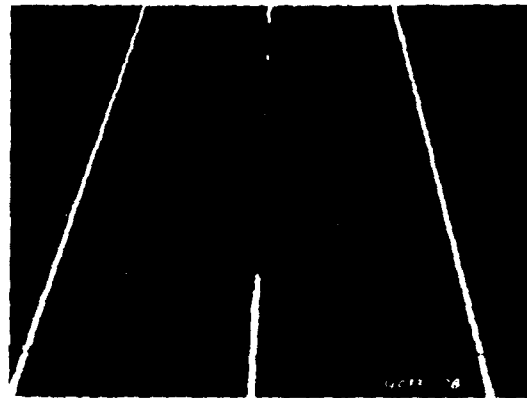
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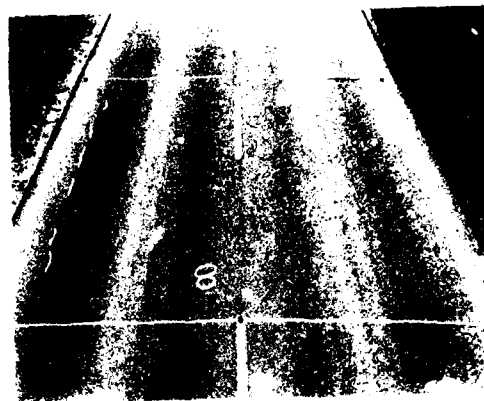


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Photo 64. Petromat fabric section, north end of Wilderness Road



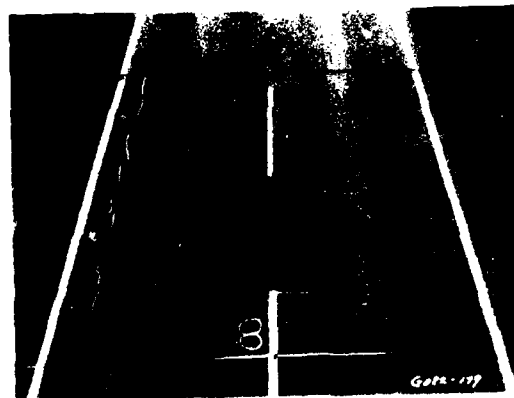
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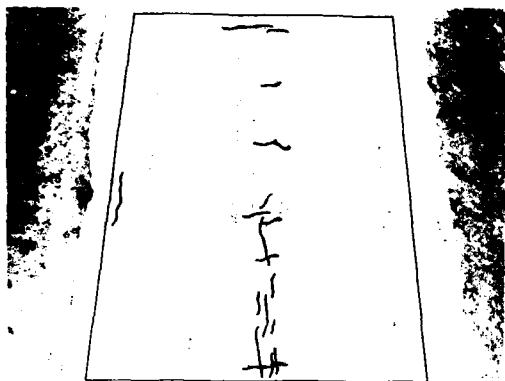


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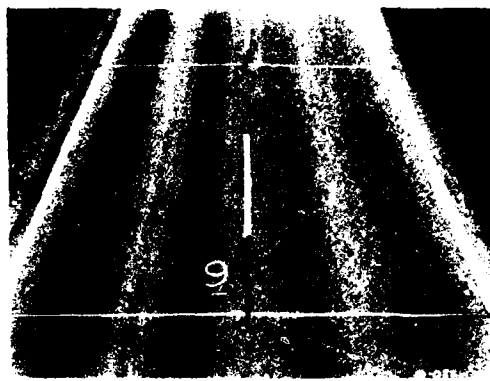


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Photo 65. Mirafi 140 fabric section, north end of Wilderness Road



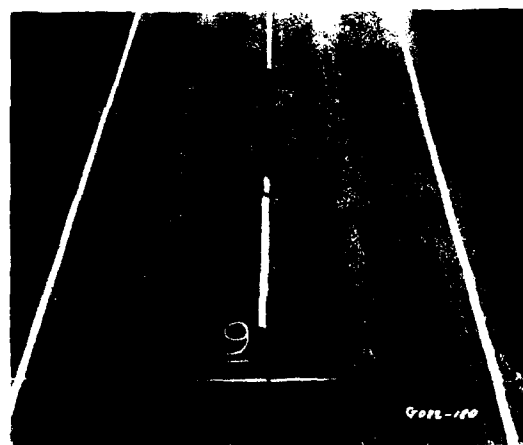
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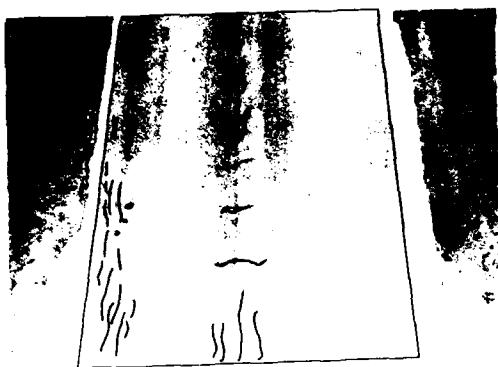


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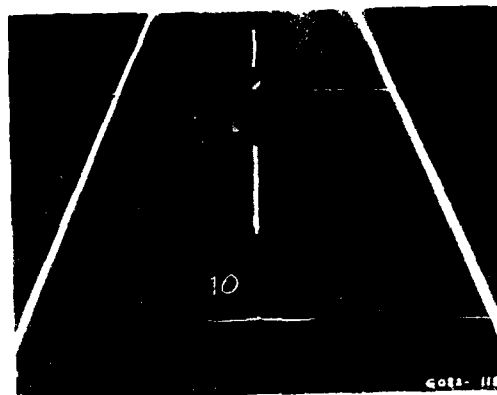


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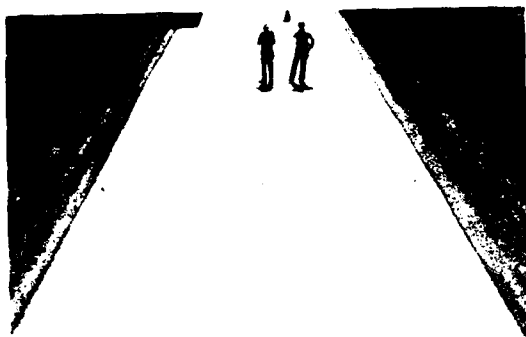
Photo 66. Bidim C-22 fabric section, north end of Wilderness Road



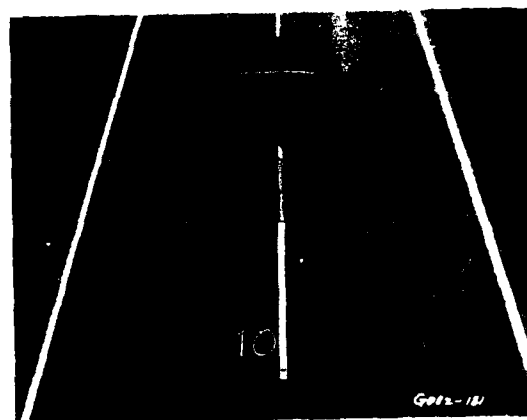
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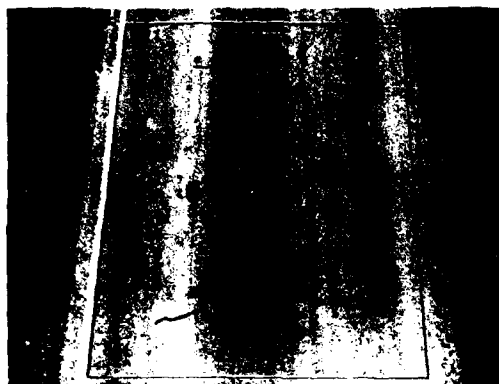


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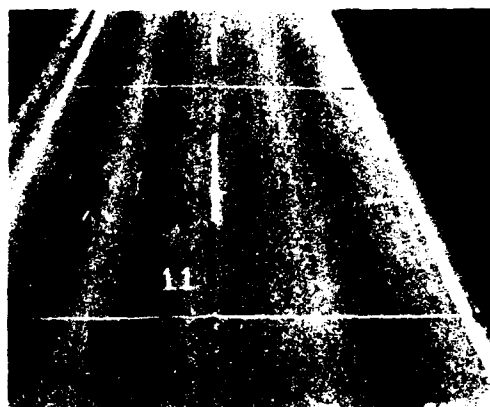


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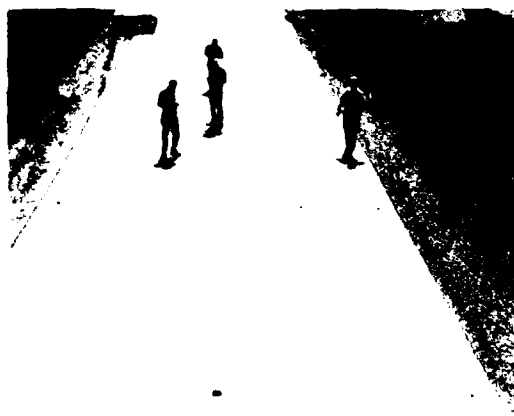
Photo 67. U. S. Rubber section, north end of Wilderness Road



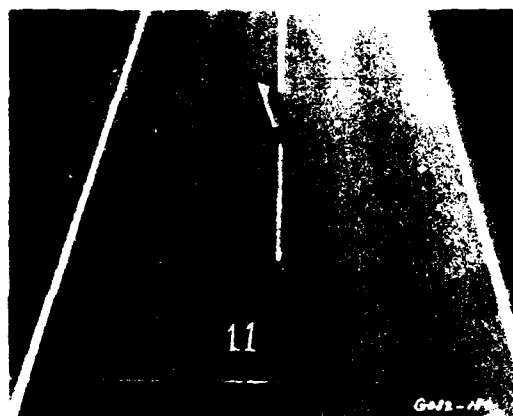
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Photo 68. Sahuaro rubber section, north end of Wilderness Road

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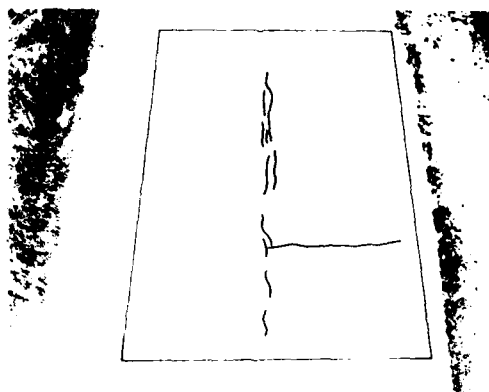
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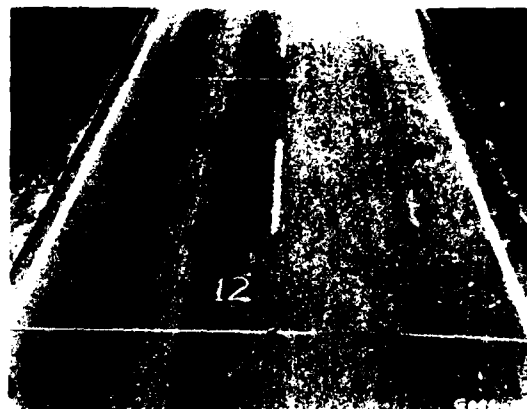
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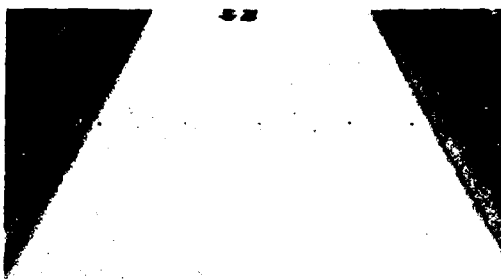
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Photo 69. Control section, north end of Wilderness Road

PART VII: CONCLUSIONS AND RECOMMENDATIONS

25. Based on the data presented in this report and the performance of the test sections over the period of time the sections were monitored, the following conclusions and recommendations are warranted:

- a. The use of an asphalt-rubber chip seal at Fort Lewis, Washington, as a wearing surface did not perform as well as a standard 1-in. asphaltic concrete overlay. Construction problems encountered with the chip seal indicate that this material should only be placed when weather conditions are suitable for chip embedment and retention. The quoted cost of an asphalt-rubber chip seal in place as of August 1981 is about \$1.50 per sq yd. The asphalt-rubber membrane, especially with the kerosene additive, appears to be a very tender mixture, and the restriction of use by traffic for a period of time may result in better performance of this material.
- b. Use of a very firm fabric, such as Mirafi 140, will cause problems under thin overlays from wrinkles, if permitted during placement. The wrinkles in the softer fabrics, such as Bidim and Petromat, did not affect the performance of the materials under a thin overlay.
- c. The trend of the performance of the materials at Fort Lewis, although very slight, indicates that possibly the use of a fabric, such as Bidim, of an asphalt-rubber membrane interlayer may help a little to retard the reflection of cracking through a thin overlay in the climate that Fort Lewis experiences.
- d. The performance of the materials in a cold environment, such as at Fort Devens, Massachusetts, indicates that none of the test materials used will stop reflection cracking from occurring through a thin overlay. The percentage of cracks reflecting through the control section was only about 10 more than that indicated for the U. S. Rubber membrane, which showed the best performance from the standpoint of the small selected areas that were monitored.
- e. The performance of the materials in a warm temperate climate, such as Fort Stewart, Georgia, was more difficult to evaluate than the Fort Devens area. The fabrics indicated a much poorer performance than the asphalt-rubber membranes. The keystone course used for a control section performed very well, but it is known from past experience that in another year or two most of the cracks will have reflected through the thin overlay in this control section. It is not known why one asphalt-rubber

area performed so much better than the other. Personnel at the installation should continue to observe these areas.

- f. The use of a fabric on the portland cement concrete roadway at Fort Polk before placement of an asphaltic concrete overlay appears to be of no value in preventing joint reflection.
- g. A general conclusion on the results of this study would be that the use of these membranes in a cold environment does not prevent or retard reflection cracking from occurring. The use of an asphalt-rubber membrane in a warm climate may have some merits, and it is recommended that the base personnel continue to observe the test areas at Fort Stewart to see if the trend of limited reflection cracking in the asphalt-rubber membranes in the future will continue.

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